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**CONCEIVING NEW INDUSTRIAL SYSTEMS:
THE DIFFERENT EMERGENCE PATHS OF THE HIGH-TECHNOLOGY
INDUSTRY IN ISRAEL AND IRELAND**

DAN BREZNITZ

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Conceiving New Industrial Systems: The Different Emergence Paths of the High-Technology Industry in Israel and Ireland¹

Dan Breznitz

Industrial Performance Center – MIT
Media Lab Europe – Dublin, Ireland
MIT Department of Political Science
Massachusetts Institute of Technology

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Introduction

In the last decade, both Israel and Ireland have been on the forefront of a successful double revolution. In the international arena, the two small states have been the hotbeds of new technology based firms (NTBF) that establish themselves in global markets in the area of software and information technology, making the two states successful participants in the so-called biggest industrial revolution of our ages. In the domestic arena, the two states' political and industrial landscapes, not models of industrial success since their independence in the first half of the 20th century, have been quickly transformed by an emergence of a new type of corporation and the financial and legal institutional structure it brought with it, the above mentioned Information Technology (IT) NTBFs.

This paper will evaluate and analyze the success of the Irish and Israeli high-tech industry, compare the very different development paths of the two industries, and present the dynamic historical dialogue between the state and private business that molded the industry. I argue that the two different histories of industrial growth and creation continue to shape the industry in the present, lend themselves to the very different models of corporation growth strategies of Irish and Israeli high-tech firms, and necessitate two different approaches of public policy to compensate and enhance for the different weaknesses and strengths of each model. Data for this paper was supplemented

with 233 open-ended interviews with founders of NTBFs, managers of MNCs, VCs, civil servants, and academics conducted in Ireland, Israel, and the US between December 1999 and February 2002.

The paper is organized as follow: the first part is a short description of the Israeli and Irish High-Tech industries, which aims to show their significant growth in the last decade and the inherent differences in their composition. The second part presents the different history of industrial policies in Ireland and Israel. I contend that the Israeli state's conscious aim was to develop an industry built around strong evolving internationally competitive R&D capabilities. Thus, the focus of the state in Israel was on developing R&D and innovation capacities throughout the innovation system, with a specific attention given to industrial R&D.¹ In Ireland, meanwhile, the state intention was to develop an industry which will create a significant number of jobs, and the education and innovation systems were developed around that focus, i.e., viewed as a supply side subcategory of an overarching industrial policy planned around job creation.

I conclude by elaborating on my argument that these two very different industrial policies and the disparate continuing dialogues between industry and state that evolved as a result, gave rise to a distinct structure of NTBFs growth in each case. I also contemplate on the different weaknesses and strengths that these legacies left Ireland and Israel.

¹ It is important to note that the competitive edge the state leaders wanted to expand was in R&D capabilities per se, not in a specific domain of knowledge. The state aimed to develop "science-based industries" in Israel with the definition of science-based being innovative R&D project taken to develop products without limitation to specific industrial sectors.

The IT industry of Israel and Ireland in historical perspective

This part of the paper will first describe and then compare the history, development and composition of the Irish and Israeli IT industries. Looking at the two industries in 2002, we see a similar landscape of strong growth through the 1990s based on growing numbers of small and medium sized NTBFs, all of which imitate to a lesser or greater degree the development path of an American start-up company. The IT industry has been growing in its importance in the two countries employing larger percentages of the workforce and contributing significant amounts of total annual GNP growth.

“Graph 1, Total sales Ireland and Israel, and graph 2 Total employment about here.”

However, one difference between the two that immediately strikes the eye is the fact that the indigenous Irish IT industry is focused almost solely around pure software companies, while the Israeli industry is divided between the older and more developed hardware and electronic sector and the younger pure software sector.²

Interestingly, the Irish software is dually structured, divided almost equally in labor size throughout the years between the Irish subsidiaries of MNCs and the indigenous sector. The MNCs are concentrating mostly on low-skilled level work like translation and localization (although a growing number of them are moving into higher level R&D work in the last four years), contributing most of the sales, and are the main reason why Ireland claims to be the second largest exporter of software in the world.³

² Aside from one successful NASDAQ listed company (Parthus, now in a merging process with the IP licensing division of an Israeli company, DSPG), few mergers (Agilent acquisition of MVT, and PMC Sierra acquisition of Toucan being the prominent ones), 2-3 medium size design houses, and about 3 promising start-ups, the indigenous Irish IT industry consists only of pure software companies.

³ Localization is the programming activity of taking an already working program in a specific culture/language and translating it into a different culture/language.

However, as can be seen in graph 3 and taking into account that the sales per employee figures for the MNCs Irish subsidiaries are more than double the relevant figures reported in the 1997 American industrial census, there is a sound basis to suspect that large amounts of the sales attributed to the Irish subsidiary of MNCs are the result of price transferring and do not represent the added value contributed by the Irish workers.⁴

Graph 3 Sales Per Employee Total about here

The Irish indigenous sector is, however, a different story. Growing slowly from its original base of capital-starved service and consulting companies in the late 1960s and 1970s, the industry saw the rise of product companies in the late 1970s and 1980s, and reached an unheard of success for an Irish owned industrial sector with over one billion US dollars in sales and seven companies doing IPOs on the New York NASDAQ in the 1990s.⁵ Moreover, the growth rates of the industry in the 1990s are impressive with an average annual growth of more than twenty percent.

The formal birth year of the industry is 1958, in that year Suicra -- the Irish Sugar Company (a state owned enterprise) -- brought the first computer to Ireland.⁶

⁴ Using NAICS codes the sales per employee figures reported in the 1997 census for Software Publishers (51121) are \$231,621, and for Software Reproducing Companies (334611) are \$156,775 the figures for MNCs subsidiaries in Ireland were \$502,556. See: www.census.gov/epcd/www/naic/html.

⁵ Irish IT entrepreneurs suffered from acute lack of capital throughout the years. The Irish banks were extremely conservative in their lending policies and the state help was almost non-existent to the service sector (i.e., software) until the late 1980s. Many of the entrepreneurs of the 1970s and 1980s have recounted tales of their need to mortgage their houses in order to secure the needed working capital to ensure their firms survival. R&D was sponsored almost solely on the base of consultancy and services revenues. Only in the second part of the 1990s with the establishment of Enterprise-Ireland, the local high-tech oriented VC industry and the success of the first few NASDAQ listed software companies, did these capital constraints improve.

⁶ For a comprehensive account of the development of the Irish software industry see: O'Riain, S. (1997). "The Birth of a Celtic Tiger?" *Communications of the ACM* 40(3): 11-16, O'Riain, S. (1999). *Remaking the Developmental State: The Irish Software Industry in the Global Economy*. *Sociology*. Berkeley, University of California Berkeley, unpublished Ph.D. Thesis., and Arora, A., A. Gambardella, et al. (2001). *In the Footsteps of Silicon Valley? Indian and Irish Software in the International Division of Labour*. *SIEPR Discussion Paper*. For an account based on clusters theory see, O'Gorman, C., E. O'Malley, et al. (1997). *Clusters in Ireland: The Irish Indigenous Software Industry*. Dublin, National Economic and Social Council.

Throughout the 1960s and early 1970s big public and private companies and organizations were the main loci of professional IT training and knowledge diffusion. Especially as at the time formal third level education was beyond the means of most young high-school graduates, and most universities didn't offer computer-science degrees. Barry Murphy, the first director of the National Software Directorate and now the CEO of Openet Telecom, echoes the claims made by many that these institutions are the unsung heroes of the industry:

Those big companies were the only institutions that were actually training people at the time; these companies were the likes of the banks and insurance companies. They gave superb training to cohorts of young people, which they all lost in five to seven years' time. These companies made an immense contribution to the Irish software industry. (Interview with Barry Murphy 11/6/2000).

In the 1960s and 1970s, the first Irish software companies were funded. Most, due to the high cost of computers at the time and the capital constraints in Ireland, concentrated either on consulting and services or on out-sourcing of IT services' business model.⁷ Slowly but surely, the first Irish companies moved on the backs of their customers into product development. Timing and the movement of the MNCs into Ireland were important catalysts in this development. In the 1970s, the MNCs led the progress in Ireland away from the mainframe platform into mini-computers. As mini-computers were a new platform and did not have an established base of software, many local companies managed to get development projects that could easily be packaged (a new concept at the time) into software products and few sales were secured in Ireland and

⁷ Interestingly enough, some of the local managers of MNCs subsidiaries claim that the existence of these IT out sourcing services companies in Ireland granted the Irish subsidiaries a comparative advantage vis a vis other subsidiaries when competing for more activities in the corporate headquarters. (Interview with John Ronaghan 7/17/2001).

the UK. The second and more important stage happened when the platform companies (e.g., Digital, IBM, and ICL) invited some Irish companies to market their products.

Kindle, one of the first Irish software companies to reach successful constant overseas sales, is an example of this model of organizational development. Kindle first developed banking systems on the ICL platform (ICL was a leading British computer company now part of Fujitsu). As ICL sold its computers around the world, especially in former British colonies, and as ICL didn't have many banking packages that ran on its platform it added Kindle to its official list of ICL software vendors as banking packages specialists. Soon thereafter, Kindle got orders from all of the former British colonies. In the second part of the 1980s, Kindle converted its products to other platforms as well. Kindle is now owned by a British company, and is a 500-people-strong software house with global sales and support network. However, its' main loci of activity and R&D is no longer in Ireland.

By the later half of the 1980s, the success of these product oriented software houses and the PC revolution, started to change the Irish landscape and more and more software companies were founded around a specific software idea. Nevertheless, as the stories of the first few years of even the most successful Irish companies like Iona, Aldiscon (now Logica-Aldiscon), and Smartforce (formerly CBT) attest to, the industry's main problem remained the acute lack of capital.⁸ Many product oriented firms had to support their R&D efforts by offering services and consulting, a fact that not only slowed their R&D efforts but limited their ability to develop large scale complex R&D based products. This situation started to change only after the reconstruction of the Irish

⁸ Interviews with: Sean Baker (7/3/2000) and Chris Horn (1/23/2001) of Iona, Patrick McDonagh founder of CBT (3/20/2001), and Gilbert K. Little founder of Aldiscon (4/18/2001).

industrial policy and the refocusing of a significant portion of that policy on the indigenous industry and not mainly on the MNCs. The formal creation of Forbairt, the forerunner of Enterprise-Ireland (EI), in 1994 increased the state support for Irish-owned software companies. In addition, starting in 1995 the National Software Directorate (NSD), now part of EI, led an initiative to distribute EU backed finance in an attempt to spur the establishment of high technology oriented Venture Capital funds. This attempt, coupled with the proof of financial gains opportunities by the NASDAQ listed companies after 1995, had culminated in a small but vibrant local VC industry. For the first time in the industry history, starting in 1999, local software entrepreneurs can reasonably expect to find enough investment capital to open a product-oriented-only start-up company.⁹

However, as can be seen from graph 4, the average sales figures per employee in the Irish indigenous sector, while vastly improving from a low of \$45,000 in 1991, is still only 40% of the average of the Israeli IT industry. This seems to imply two points: first, looking from an optimistic point of view, there is still a lot of room for improvement; The second is that a larger percentage of the Irish industry is still focused on the less profitable activities of service, consulting, and bespoke development.

Graph 4 Sales Per Employee IT about here

Of the two indigenous IT industries, the Irish and Israeli, the Israeli IT industry is the older with the hardware IT sector preceding the pure software sector by more than a decade. The Israeli industry also followed a very different business strategy from the Irish

⁹ Good statistics are lacking but using multiple resources we can ascertain that starting in 1999 a major upgrade of the VC market occurred. About 700 million euros were raised by Irish IT oriented VCs in the 2000-2001 period, with actual investment in IT of 62 million euros in 1999 and 162 million euros in 2000. Sources: M.O.P (2000). Report on Irish Venture Capital Industry. Dublin, Matheson Ormsby Prentice and the Irish Venture Capital Association, PriceWaterhouseCoopers (2000). Money for Growth: The European Technology Investment Report 2000, PriceWaterhouseCoopers., Irish Venture Capital funds websites.

one. From its inception the industry was a product based export oriented one. As early as 1972 an Elron group company, Elscient, a medical imaging company, using a strategy conceived by Fred Adler, an American Venture Capitalist, to compensate for the lack of VC funds in Israel by raising money through an IPO, listed on the NASDAQ. This early move of Elscient, which occurred three years after its founding and less than two years after it produced its first medical imaging device, symbolizes more than anything the very different development paths of the Irish and Israeli IT industries.¹⁰

Of the two broadly defined sectors of the Israeli IT industry, electronics and hardware and pure software, the electronics and hardware sector is by far the larger.¹¹ With 55,800 employees and \$12.5 billion in sales in 2000, the hardware sector is about four times larger than the software sector. The two sectors seem to have followed the same growth trajectories in the 1990s, the software industry growing at an average annual rate of 23%, and the hardware at around 15%. However, the average sales per employee figures in the software sector quickly grew to narrow the initial gap between the two, with average sales per employee in the software sector surpassing the hardware ones for the first time in 1997. Moreover, the average sales per employee figure in the Israeli IT sector compare very well with the American one and are more than twice as big as the Irish one. It is important to note, however, that the dividing line between the two sectors

¹⁰ For more on the early electro-medical industry in Israel see: Teubal, M., A. Naftali, et al. (1976). "Performance in Innovation in the Israeli Electronics Industry: A Case Study of Biomedical Electronics Instrumentation." *Research Policy* 5: 354-379., and Teubal, M. and P. T. Spiller (1977). "Analysis of R&D Failure." *Research Policy* 6: 254-275. For a history of the semiconductors history in Israel see: Autler, G. H. (2000). *Global Networks in High Technology: The Silicon Valley-Israel Connection*. *City and Regional Planning*. Berkeley, University of California Berkeley, unpublished Master thesis. For a journalistic, partial, descriptive history of Israel high-technology industry see: Levav, A. (1998). *The Birth of Israel's High-Tech*. Tel-Aviv, Zemora-Bitan. For two accounts which briefly discuss the software industry and the causes of its success see, Ariav, G. and S. E. Goodman (1994). "Israel: of Swords and Software Plowshares." *Communications of the ACM* 37(6): 17-21., and, de Fontenay, C. and E. Carmel (2001). *Israel's Silicon Wadi: The Forces Behind Cluster Formation*. *SIEPR Discussion Paper*.

¹¹ However, one must remember that out of the total R&D effort in the electronic and hardware sector up to 50% is software-related.

is far from impassable. An example is Comverse Technologies, today considered to be one of Israel's most successful software companies, which was offering only hardware solutions in the first few years of its operation.

The official history of IT and computing in Israel began before the creation of the state as an independent national identity. In 1947 the Advisory committee of the Applied Mathematics Department of the Weizmann Institute (then still known as the Seiff Institute), consisting of Albert Einstein, Hans Kramer, Robert Oppenheimer, John Von Neumann and Abram Pais, recommended that the Institute build an electronic digital computer, making Israel the first not-yet-a-state to commit itself to computing (Ariav and Goodman 1994). However, the 1948 independence war and the continuing security threats quickly propelled the development of IT in Israel toward a different track. While the Weizmann Institute of Science continued to develop three generations of scientific computers called the 'Golems', very quickly the defense apparatus and the state bureaucracy became the torchbearers of IT development in Israel.¹²

Probably the first unit in the Israeli defense complex that started to develop and use IT was RAFAEL (the Hebrew abbreviation of: Armament Development Authority). RAFAEL, the first, leading, and for many years almost the only body in Israel that did applicative high-tech R&D, had already started to use computers in the 1950s.¹³ In 1956

¹² For more about the impact that the Israeli military had on the software industry see, Breznitz, D. (2002). *The Military as a Public Space – The Role of the IDF in the Israeli Software Innovation System*. [MIT-IPC Working Paper](#).

¹³ The story behind the formation of RAFAEL is also of interest as it illuminates the intimate relations and importance that prominent scientists had on public policy in the decades before and after Israel's independence. The initiative to create a special "science corps" was presented by two professors to David Ben-Gurion, the leader of the biggest Zionist organization in pre-independence Israel and its first Prime-Minister, before the 1948 independence war. In 1958, the science corps were separated from the Israeli Defense Forces and another prominent bio-chemist from the Weizman institute, Aharon Bergman, stayed on as its first head (with Munya Mardor as its first MD). For a history of RAFAEL first years see, Mardor, M. M. (1981). [RAFAEL](#). Tel Aviv, Ministry of Defense of Israel Press (in Hebrew).

RAFAEL, then still a part of the Israeli Defense Force (IDF) developed an analog computer. In 1959, a more sophisticated analog computer, "Itzik," was developed in order to enable larger scale simulations. In the end of the 1950s RAFAEL developed a few digital computers.

RAFAEL and the people behind its formation played two more important roles aside from being an important source of information diffusion in the areas of science and technology and in the areas of R&D management (for example, REFAEL pioneered the use of Operation Research and project management techniques like P.E.R.T in Israel), and spin-offs. First, the leading scientists behind its formation were the same people who formulated Israel's high technology and R&D industrial policy in the end of the 1960s. Secondly, RAFAEL was used by the state as an incubation center with which it "infected" other defense and civilian companies and organizations with IT R&D capabilities. The most important of these were: the creation of the IDF's computer unit (MAMRAM) in 1960 (Breznitz 2002). The first attempt in 1962 to upgrade the Israeli Aircraft Industries (then known as Aircraft Maintenance Corporation) into high technology based company with the relocation from RAFAEL of the whole project team that developed the Gabriel – the first Israeli sea-to-sea radar guided rocket. Last but not least, was the creation, in a joint venture with the Elron group, of a high-tech start-up called Elbit in 1996, the R&D basis for which was created by the relocation of the whole digital computer development team of RAFAEL to Elbit.¹⁴

¹⁴ Elbit's first product was a mini-computer that competed head to head with Digital's, later Elbit moved toward a more defense-oriented markets and is now Israel's largest defense high-technology company. In 1983 Elbit first listed on NASDAQ, as of 2002 three of Elbit's companies -- Elbit Medical imaging, Elbit Ltd. and Elbit Vision system -- are listed.

In the private market, two interesting parallel developments occurred. First, while most of the banks and investment companies behaved in a way similar to the Irish ones and did not agree to invest in the IT industry, there was one critical exception: the discount bank investment group, now known as discount investment. At the time, the discount group was called the Israeli Company for Investment and Finance and was headed by Dr. Augusto Levi. Italian born and educated Dr. Levi, decided, unlike his Israeli educated counterparts in the investment community, to follow the export-oriented industrial investment model of the Italian banks. In the beginning of the 1960s the group was joined by Dan Tolkowsky who left the IDF after commanding of the Israeli Air Force. Tolkowsky became instrumental in moving the discount group into high technology investment. In 1961 he first met Uzia Galil, the founder of the Elron group, and throughout the 1960s and 1970s the Elron group and Discount become the main source of NTBFs in Israel. Elron, Elbit, and Elscient, all of which later managed an IPO on NASDAQ, were created by Galil with Tolkowsky as the manager of Discount Investment being their chairperson. Tolkowsky also managed to convince Discount to get involved with almost all of the NTBFs started in Israel at these times, such as like Scitex and Iscar.

Tolkowsky was also crucial at another critical juncture for the Israeli IT industry. By the end of the 1960s after doing some business with the Rockefeller's Venture Capital arm, he had realized the Israeli industry's need for experienced VCs with larger funds than what Discount could master. In 1971, Tolkowsky decided to fly to the US to interest the then still young VC industry in investing in Israel. Knowing that on merit alone he would limited chances, he decided to approach Arthur Rock, which was

not only one of Silicon Valley's most famous VCs (Rock was crucial in securing the finance for Fairchild semiconductors and Intel, and later become involved in Apple, to name just three) but, even more importantly for Tolkowsky, was Jewish. Rock was unwilling to invest in anything that was not in Silicon Valley. However, he did introduce Tolkowsky to the second famous Jewish VC of the Time, Fred Adler of New York (Adler was involved in Applied Materials and Data Systems at those times). Adler still remembers Rock's phone call:

I got a phone call from Arthur about Dan Tolkowsky, he told me that Dan is seeking someone to invest in Israel, and he said "I told him that I am not willing to invest in anything which is not in California, but that I should introduce him to you, you are known as crazy, you might be crazy enough to do that." He then told me about Dan and his background: a fighter for the British RAF in WWII that became the commander of the Israeli Air Force. You must remember it was only three years after the 1967 war and I must admit that it got me so interested in the man himself that I wanted to meet him just because of that. (Interview with Fred Adler 9/28/2000)

Adler visited Israel and become involved first with Elscient. Realizing the futility of his efforts to raise VC for the company, Adler decided to jump-start the whole process by bypassing the VC stage altogether and raising money through an IPO. Adler assumed that after few successful IPOs the Israeli industry would look more inviting to American VCs and the VC problem would be solved. Little did he know at the time that this process will take more than two decades.¹⁵

Another critical point was reached in 1968. Following the sudden French military embargo, the state channeled large investments and R&D power into military high technology efforts. Similar changes followed in regard to the civilian R&D industrial policy. Israel's first committee on science and technology industrial policy -- the Katchalski Committee -- was convened at the request of the Prime Minister Levi

¹⁵ To verify this account interviews were conducted with Dan Tolkowsky 6/7/2000 and 8/10/2000, Uzia Galil 8/9/2000, and Fred Adler, 9/28/2000 see also Levav, Ibid, and Autler, Ibid.

Eshkol. The Katchalski committee argued for the establishment of the Chief Scientist Offices in the main government ministries. The most important of which was the Ministry of Trade and Industry Office of the Chief Scientist (hereby: OCS). The OCS defined its objective as fixing a market failure in the area of civilian industrial R&D and provided a flat 50% of cost in conditional loans for any approved industrial R&D project originating from the private industry aimed at developing a new exportable product. The loan was payable only if the R&D project ended with a profitable product.¹⁶

However, even with the best efforts of the private financial and technological entrepreneurs like Tolkowsky, Galil, and Adler coupled with the assistance of the OCS, the industry remained cash starved. The software sector suffered the most; viewed as a service it was not entitled to OCS grants until 1985. Moreover, until the 1980s, as the fact that the OCS did not managed to distribute all of its annual budget can attest, the problem was not only of capital starvation, but lack of willing entrepreneurs. In its special 1975 policy document the OCS described this lack as an acute problem:

It is evident that despite the opportunities described in this section on the one hand, and the massive government support on the other, too few new technology-intensive industries are being established... Clearly we have here *a problem of technological entrepreneurship*. Despite opportunities and massive government aid, there are not enough people willing to take the risk. To reach the ultimate goal of industrial R&D, i.e., new increased exports, *particular attention must be given to this phenomenon as well.* (OCS 1975)

¹⁶ For the OCS earlier definition of its own role as fixing market failure in civilian R&D see, OCS (1975). Industrial Research and Development Background and Policy. Jerusalem, Ministry of Commerce and Industry - Office of the Chief Scientist., and, OCS (1977). Industrial Research and Development in Israel: Policy and Issues. Jerusalem, Ministry of Commerce and Industry - Office of the Chief Scientist. For a analysis of the OCS systems in its early years, the logic behind it, and effects of its industrial sector “neutrality” see, Teubal, M. (1983). "Neutrality in science policy: the case of sophisticated industrial technology in Israel." *Minerva* **21**: 172-197., and, Teubal, M. (1997). "A Catalytic and evolutionary approach to horizontal technology policies (HTPs)." *Research Policy* **25**: 1161-1188.

In the 1990s the situation finally changed. In the first half of the 1990s, the OCS initiated four new programs: Inbal (1991) and Yozma (1992) to spur the local VC industry, the Technological Incubation Program (1991) to spur very early stage entrepreneurship, and the MAGNET (1994) program to induce university-industry and intra-industry large scale R&D cooperation. Graph 4 attest to the fact that VC finance is no longer a problem in Israel with the VC industry growing in size and funding to become one of the largest per capita industries in the world with an unprecedented \$3.288 billion raised by Israeli VCs in 2000 alone. In addition, the success of these OCS programs and the demonstration effect of the successful wave of NASDAQ IPOs in the first half of the 1990s has spurred an unheard of entrepreneurial activity in Israel with the rates of annual new start-up companies formation reaching 400 in 1990-2000, and the total number of start-up companies in Israel assumed to be between 3500 to 4000 in 2000.¹⁷

Graph 5 - Capital raised by Israel VC 1990-2000 about here

Despite the fact that those developments indeed indicates the great success and growth of the Israeli IT industry, the particular development path chosen by both the state and the industry, with its' extremely close connection to the US for the last three decades is not without problems. In the last half of the 1990s more and more Israeli companies had decided to incorporate in the US and are now for legal and more importantly for taxation proposes are treated as US companies with an Israeli subsidiary.¹⁸ Moreover, as

¹⁷ Data on start-up activities and formation should be taken with a large dose of skepticism but the same figures are constantly presented by both state and industry association organizations, furthermore, with a growing amount of start-ups receiving finance either from established VC funds and the OCS there is a good reason to assume that these figures do not stray from the truth to a very large degree.

¹⁸ For obvious reasons accurate data on these new Israeli born US incorporated firms is hard to get be, but according to most VCs interviewed, in the period after 1998 a turning point was reached with over 50% of companies incorporating in the US. With the current downturn in the fiscal markets and the reemergence of

more and more successful companies realize that the US is their main market, they move more and more functions and activities to the US; in effect turning themselves to a quasi-American MNC with its main R&D labs in Israel. These development pose an obvious problem for the future development of the IT industry in Israel, but it still remains to be seen to what degree this NTBFs migration process will continue, especially under capital market conditions that do not suffer from excess boom.

In summary, the Irish and Israeli IT industries both show a tremendous growth throughout the 1990s and are seen by many as the main engine of growth for the whole economy in these years. Moreover, the IT industry in both places is the first case in these two states histories of an indigenous industrial sector to achieve worldwide success and the first in both to spur a large scale local private entrepreneurial activity aimed at world markets. Nevertheless, aside from the difference in size that can be attributed to the fact that the Israeli industry started two decades before its Irish counterpart, three striking differences emerge when one compares the Irish and Israeli IT industries.

The first is that the Irish owned IT industry is almost solely concentrating around pure software companies, while in Israel the software industry plays an important role, but it is the youngest and the smallest branch of the IT sector with hardware and mixed products companies in various fields from the medical to the electro-optical taking the lead.

The second is that while the same MNCs operate in both countries and many times started their Irish and Israeli operations in almost the same year, there is a marked difference in their importance and in the scope of their activities in each location. In

OCS grants as a critical source of capital this trend had slightly truncated in 2001, see also Harmony, O. (3/3/2002). Delaware is moving away toward the horizon. [Ha'aretz \(hebrew\)](#).

Ireland the multinationals employ most of the workforce even in the software sector and have most of the sales, but concentrate almost solely on low-end activities like manufacturing and localization, with R&D activities being developed slowly after a few years of the specific MNC operations in Ireland. In Israel most MNCs first move in order to start R&D activities, either by building an R&D center or by buying Israeli start-ups with certain technologies and transforming them into an R&D division within the organization.¹⁹ Two examples should serve to highlight this difference and to show the different ways in which MNCs continue to develop their operation in each location in accordance with their global strategy: Intel and 3Com. These companies were chosen as in both places they pioneered what later became a regular mode of operations for other MNCs, and in the case of Intel the influence and lessons from its move to Israel were later put to use by the local management in Ireland.

In 1974, Dov Frohman, an Israeli senior researcher in Intel CA headquarters, decided to return to Israel and accept a professorship in applied physics in the Hebrew University of Jerusalem.²⁰ As Intel didn't want to lose Frohman, the company decided to pioneer and opened the first outside US design and development center in Israel with five employees.²¹ Unknowingly, by doing that Intel also pioneered a mode by which many MNCs started operations in Israel. Over the years the center was highly successful and continuously enlarged its R&D activities to encompass in 2002 seven centers. In 1985,

¹⁹ For more about the R&D activities of MNCs in Israel see, Felsenstein, D. (1997). "The Making of a High Technology Node: Foreign-owned Companies in Israeli High Technology." *Regional Studies* 31(4): 367-380.

²⁰ In 1971, shortly after joining Intel in 1969 and after the first 1kbit DRAM was released, Dov Frohman invented the UVEPROM, an electrically programmable memory that holds the programmed values until erased by intense ultraviolet light. Frohman invented, developed, designed and fabricated the first UVEPROM.

²¹ One must note though that opening a small SC design center is not a capital-intensive high-risk decision like opening a fabrication facility, total investment in the Israeli center was \$300,000 (1974 terms).

Intel Israel also pioneered the first movement of Intel toward CPU fabrication activities outside the US with the first Intel Fab in Israel starting operation in Jerusalem. In 1999, Intel started the operation of its second Fab in Israel and in 2000, following the acquisition by Intel of two companies with major R&D centers in Israel, DSPC and Dialogic Israel, Intel R&D activities in Israel have evolved into two more product platforms. Beyond these activities, Intel Capital activities in Israel are the largest in term of investment outside the US. Throughout the years, Intel Israel R&D was responsible for some critical components in Intel's global strategy like the 8088 (IBM's famous pick as a CPU for its first PC) and the Pentium MMX technology. In 2000, Intel Israel had revenues of \$2 billion and employed 4,000 people; as of 2001 Intel Israel was responsible to the development of the next generation laptop oriented CPUs, 3G mobile networks products and few others a critical components of Intel global R&D strategy.

In 1989, Intel decided to start manufacturing operation in Ireland. The first operations were low-level assembly. The main reason behind Intel's decisions to locate in Ireland at the time was the company fear of an imminent creation of "Fortress Europe" by the EC (now EU) in 1992. A year after the first box assembly operation began, Intel decided to open a full scale Fab in Ireland, making Ireland at the time the only other place besides Israel with an Intel Fab. A few years after Intel realized that "Fortress Europe" was not an imminent danger, the box assembly line was closed down. However, fabrication activities remained. Moreover, local management, spurred by the shock of the closure and helped by an Israeli who became the Fab developer and manager and building on his experience in Israel, started low profile R&D activities aiming at the

creation of a center of excellence in particular technologies in Ireland.²² Intel Ireland also managed to lobby Intel HQ to create a special position for Intel Capital in Ireland, which started operation in 2001, already invested in a couple of local start-ups.²³

3Com involvement in Israel enlightens the second and newer route used by MNCs to start operation in Israel. In 1994 3Com bought NiceCom, an Israeli company that developed LAN ATMs and became the NiceCom division inside 3Com responsible for all ATM technology in 3Com. 3Com enlarged their Israeli NiceCom R&D center with a few more successful M&As and ended with a critical mass of 300 people in Herzelia. In the end of the 1990s 3Com became a large complex company and suffered from growing financial difficulties. As a result, 3Com started a spin-off process in which it spun-off among others, Palm; its modem business under the old US Robotics brand (which it bought with the acquisition of US Robotics, another company who had an R&D center in Israel); and in February 2000, Atrica. Atrica is a new Israeli start-up building urban optical networks and headed by no other than the old NiceCom executive team. As of 2002 Atrica inherited all of 3Com's R&D activities in Israel and is considered one of Israel's most promising start-ups and managed to secure more than \$100 million in investment. Moreover, the former CEO and now chairman of 3Com and CEO and Chairman of Palm, Eric Benhamou, serves as Atrica's Chairman.

3Com started its Irish operation in 1992 as part of its "Fortress Europe" strategy by opening a plant in Dublin. Over the years the Dublin operation became the best in

²² Interestingly the next and present job of the Israeli in question is managing Intel Capital Israel.

²³ The constructed history of Intel in Ireland and Israel is based on interviews with five executives of Intel and Intel capital in Israel and Ireland, and email communication with Dov Frohman, Dror, Y. (2/6/2002). Intel develops in Israel a cellular laptop. *Ha'aretz (In Hebrew)*, Wired Magazine "Tech New Promised Land," 1/17/2000, also available on line, <http://www.wired.com/news/infostructure/0,1377,33537,00.html>, and Intel Israel and Intel Ireland websites: <http://www.intel.com/il/> and <http://www.intel.com/ireland/>.

quality and yields, and 3Com also opened a small R&D center in Dublin. It is an interesting fact that even as 3Com was reeling from 18 months of downsizing in 2002, the Irish R&D center is still operative and that although 3Com has outsourced all of its manufacturing activities mainly to Flextronics and closed down all of its other plants worldwide, the Irish plant is still working. According to 3Com, the reasons behind this decision are a mix of the high quality and yields for the Dublin plant in addition to the Irish tax regime, the fact that Ireland is part of the EU and that they found the infrastructure around Dublin to be excellent for European deliveries, and last but not least, the excellent relationship with the Irish government.²⁴

The third very interesting difference in the historical development of the two industries is most salient when we compare the growth of the software industry in the two locations. It is evident that a major feature of the Israeli software industry is the large role that the local market played in its development. That market was already well developed in 1984 with 370\$ millions in sales, while export sales started with only 5\$ millions. Local demand continued to develop, inducing tremendous growth in local software sales throughout the 1980s to the 1990s. To clarify how the local market was already relatively large before the export boom began, it might be worthwhile to note that in 1991 the local sales of the Israeli software industry were \$540 million; only in 1997 did the total sales (export and local) of the indigenous Irish software industry reach parity in nominal term with 585\$ millions.²⁵ Accordingly, when we compare Israel to Ireland, we see that while the size of the Israeli software industry in the 1990s was vastly larger, Israel's exports

²⁴ Sources: interview with Eric Benhamu former CEO and Chairman of 3Com 1990-2000, and present Chairman of 3Com, Chairman and CEO of Palm, and Chairman of 3COM 2/13/2002, Harmony, O. (2/14/2002). Atrica, funded by 3Com, raised \$75 million. *Ha'aretz*. Asis, Y. (2/20/2002). Above the rest. *Ma'ariv* (In Hebrew)., and company's website www.3com.com.

²⁵ In real term the parity was probably reached only in 1998.

became larger than its local sales only in 1997, where is Ireland's exports for most of that period were around 60%.²⁶

Table 1 – Software Sales and Exports Israel and Ireland

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Irish-owned exports	70	101	132	195	258	334	410	509	713	788
Irish-owned sales	172	221	270	356	441	513	585	822	1150	1269
Israel exports	110	135	175	220	300	600	1000	1500	2000	2500
Israel sales	540	600	700	800	950	1300	1780	2350	2950	3700

Sources: National Informatics Directorate, Ireland, Israel Association of Software Houses

Note: Until 1997 data in Ireland was collected every two years.

The last difference on which we should focus in this paper is the different development paths of the Venture Capital Industry. As the state in both countries played an important role in the creation of the VC industry, the next part of the paper describes the historical development of the industry. For now we should note one important difference in regard to the sources and the VC management companies. The major sources of financing of the Israeli VC funds is the US with smaller amounts of money arriving from Asia and Europe and still smaller amounts from Israel. Moreover, almost all of the big funds maintain an office in the US, and all claim to have close working ties with US VCs and big technology companies. In addition, the majority of general and managing partners of most of the VC firms come from the IT industry. In Ireland, most financing of the Irish VC firms originates in Ireland itself or from European investors, with only one fund bringing a substantial amount of money from the US. In addition, many of the funds are tied to established banks or financial institutions, and only very

²⁶ It is interesting to see, however, that local sales had gained in importance in Ireland while stabilizing in Israel. This might point to the fact that in Israel the market for IT was already well developed by the second half of the 1980s, giving the Israeli software industry the needed spur and testing ground to move forward. In Ireland an opposite process seemed to occur, with the export based IT boom prompting the local market, which was underdeveloped (the sales by MNCs in Ireland seems to strengthen this argument rising from less than \$40 in 1997 to almost \$1 billion in 2000).

few of the managing and general partners have any industry experience, with the average profile being in accounting or management consulting.

The History of Science and Technology Industrial Policies in Ireland and Israel

This part of the paper presents an historical description of Israel and Ireland's industrial policies, with a particular focus of these policies aimed at the IT and science and technology sectors. I argue that the differences in these industrial policies stem from inherently different conceptions of the state's economic problem held by policy makers in the two states. Further, I argue that the influences of the two development paths of industrial policies are far-reaching, as they created a different institutional framework in which NTBFs developed and operated for the last three decades in both countries. In addition, I argue that these industrial policy gave birth to a nascent IT sector in the two countries which, as it grew, started a very different dialogue vis a vis the state and further influenced the growth of the sector in the two states.

Since independence, the Republic of Ireland passed through two almost full U-turns of its industrial policy, and a subtler, but arguably at least as important, transformation since the beginning of the 1990s. For the first decade of its existence, the Irish state, led by William T. Cosgrave of the Cumann Na nGael party, followed an economic policy focusing solely on the agriculture sector, and was fiercely free trade in its ideological base. Patrick Hogan, the then Minister for agriculture, is famous for describing this policy as "helping the farmer who helped himself and letting all the rest go to the devil" (Haughton 2000). The main elements of this policy were: free trade, parity with the English Sterling, low taxes, and low and modest government spending and

intervention. This policy gave the Irish an almost unbeatable claim to the title of the most conservative revolutionaries in history.²⁷

In 1932 in the midst of the global depression, staging a major political transformation in Ireland Fianna Fail -- the nationalist party -- won the elections. Fianna Fail, led by Eamon de Valera with Sean Lemass serving by his side as Minister for Industry and Commerce, made the first complete reconstruction of Ireland's economic policy and devised a highly nationalistic policy based on the ideal of an autarkic market. Free trade was abolished, high tariffs were put in place and a proxy economic war was waged for a very high economic price against England over land annuities. While some debate still exists on whether these economic policies were truly damaging to Ireland or only slightly so, one fact remains clear. The economic gap between Ireland and the UK grew and more importantly, so did the gap between the North of Ireland and the Irish Republic. Moreover, net emigration continued at an alarming pace (by 1961 the Republic population was only 2.8 million compared with 3.1 million in 1921), and an overall pessimism about the future was deeply felt in Ireland. At that time, at the request of Sean Lemass, who became Prime Minister -- Taoiseach -- after de Valera, Ken Whitaker, Ireland's most prominent civil servant, published in 1958 Ireland's first comprehensive economic policy document -- the celebrated *Economic Policy*.

In this report, Whitaker devises the main points that would continue to shape Irish economic policy to this day: export oriented industrial policy tied with free trade and conceptualization of Ireland's main economic threat as severe unemployment leading

²⁷ For more on the Irish economic history see, O'Gr'ada, C. (1997). *A Rocky Road: The Irish Economy Since the 1920's*. Manchester, Manchester University Press., and, Haughton, J. (2000). The Historical Background. *The Economy of Ireland: Policy & Performance of a European Region*. J. W. O'Hagan. Dublin, Gill & Macmillan Ltd.: 2-46.

to alarming large net emigration.²⁸ Thus, the main goal of the first economic program and those that followed was job creation. Since 1958, there were three basic elements in the Irish economic policy: provision of economic incentives and low corporate tax rates to induce industrial development and investment, transition to free trade, and -- the main cornerstone of Irish industrial policy until the mid 1990s -- attraction of MNCs (mostly American) to locate export-oriented manufacturing activities in Ireland. The most important institutionalization of this policy was the creation of the IDA, the Industrial Development Authority. The IDA mandate at the time was to create industrial jobs for lowering costs. The focus on FDI-MNCs-based industrial expansion developed in time and was not the main aim of the IDA in its inception.

This policy turnaround, coupled with a focused industrial policy that aimed at bringing MNCs into Ireland, followed by a membership of the EU since 1973, and Ireland's joining the European Monetary System in 1979, led to relative economic growth in until the 1980s. However, while manufacturing output growth was quite stable throughout the years, employment growth stayed slow and even took a dip in the 1980s. Moreover, the macro-level aggregation hides an even more devastating fact of Irish economic performance until the 1990s: the huge jobs' turnaround i.e., amounts of job lost, especially in the indigenous sector.²⁹ In the 1980s the "growth without jobs" crisis

²⁸ Emigration was so severe that it led the Irish government to organize special committees on the subject, and some observers, most notably John O'Brien in the edited 1954 volume; *The Vanishing Irish*, questioned at the time the viability of Ireland as an independent state. In the 1958 economic program which followed Whitaker's report the government described Ireland's main problem as, "Production has not been increasing fast enough to provide employment and acceptable living standards for growing number of our people; *large-scale emigration* has been accompanied by a high level of unemployment. *Emigration will not be checked* nor will unemployment be permanently reduced until the rate of increase in national output is greatly accelerated." (Economic Development, 1958, Stationary Office, Italics added).

²⁹ For an assessment and historical description of Ireland's industrial policy, see O'Sullivan, M. (2000a). Industrial Development: A new Beginning? *The Economy of Ireland: Policy & Performance of a European*

coupled with the failure of fiscal expansion policies left Ireland in a dire situation.

Emigration reached new heights with 44,000 or 1.1% of population leaving Ireland in 1989 alone.

This turn of events together with a growing resentment among the Irish on the IDA's focus on MNCs with its relative disregard of the indigenous sector started subtle but important changes in Ireland's industrial policy, which in the end, refocused it around the high technology sectors in the 1980s and 1990s. Before we turn our attention toward these changes we must, however, note the changes in another important domain, which had a critical influence on the development of the Irish IT sector, education.

Until 1966, when the Minister of Education, Donogh O'Malley, following a heated debate started by a 1965 OECD sponsored survey, *Investment in Education*, decided by decree that second level education was to be given free to all Irish children, less than 50% of the Irish population enjoyed education above the 6th grade.³⁰ This change was the first in a series of changes that overhauled the Irish higher education system, first in the 1960s and continuing in a more vigorous fashion in the 1980s after the IDA included education policy in its overall view of the supply side of the Irish industrial policy.³¹ If in the 1950s only 33% of the Irish school leavers finished secondary education and only 10% had any experience of third level education, by the mid 1990s these levels grew to 80% and 50% respectively, and the percentage among 27-year-olds and younger people attending college in Ireland is one of the highest among OECD

Region. J. W. O'Hagan. Dublin, Gill & Macmillan Ltd.: 260-282., and O'Sullivan, M. (2000b). "The Sustainability of Industrial Development in Ireland." Regional Studies, **34**(3): 277-290.

³⁰ Some argue that O'Malley had the blessing of Lemass who wanted to make sure that second level education is granted to all Irish youth and knew that he better circumvent a public debate in which the Ministry of Finance might delay or prevent this change from taking place.

³¹ For a detailed account of the development of the Irish High Education system see, White, T. (2001). Investing in People: Higher Education in Ireland from 1960 to 2000. Dublin, Institute of Public Administration.

countries (Breathnach 1998). In short, in two generations Ireland has changed from being the Western European country with the least educated workforce to being a country with one of the best educated. However, in one important respect, academic research, Ireland is still far behind and only in the last years a small positive change seems to have occurred.³² Thus, although the development of the Irish education system is unprecedented in Irish history and vastly helps to propel Ireland along the track of high skilled IT industrial development, it appears that the strategic view behind these developments saw the education system as a supply side issue, therefore mainly as a way to produce a necessary factor – high skilled labor, and not as a source of innovation and research. The last five years have seen a tremendous change both in conception and resources devoted into making the Irish high education system a more research-oriented one.

The last restructuring of Irish industrial policies around the high-technology industries started in the latest Irish economic crisis. In the beginning of the 1980s, few major policy and social upheavals started the realignment process of Ireland's institutional system along the path of NTBFs-oriented industrial development. In the socio-political arena resentment toward what was seen as the excessive focus of IDA on the MNCs with much smaller amounts of resources channeled to the indigenous industry, coupled with the severe crisis of the Irish industry, culminated in the Telesis report. The report, commissioned by the National Economic and Social Council (NESC), hence, with substantial political support behind it, argued for an almost complete renovation of the Irish industrial policy. It argued that Ireland's economic growth should have a "double engine" of FDI and Irish-owned companies. The report also argued for the building of

³² NSB (2000). Science and Engineering Indicators 2000, National Science Board. Figures 6-55 to 6-61.

national champions and that the level of organizational and management capabilities of Irish firms is too low for them to succeed without a hands-on industrial policy. Nevertheless, the report itself didn't give any conditions whatsoever as to how these national champions and winners should be selected and how the state can strengthen their management and organizational capabilities. The report was published in February 1982 and a heated debate about industrial policy evolved. However, in the 1984 White Paper on Industrial Policy, the Telesis report recommendations were mostly ignored (O'Sullivan 2000b). The main effect of the report at the time was the creation of several programs in the IDA; the most important of which was the strengthening of the Enterprise Development Program, which was a proactive department inside the IDA and became the forerunner of Enterprise-Ireland's investment arm.

The report's long-term impact was larger than what it seemed at the time, as it started, and lent legitimacy to, a long process of refocusing the industrial policy around the indigenous industry. This process culminated in another committee report, the 1992 Culliton Report. The Culliton report's most important recommendation was that the state should direct its assistance into fixing general financial market failure, i.e., helping companies in every field that were deemed too risky to be granted finance from existing conservative financial institutions. Moreover, the Culliton Report envisioned a restructuring of the development agencies' organization. As a result of this report two waves of bureaucratic reshuffling occurred. In the first, under the Industrial Development Act of 1993, the IDA was restructured into two main agencies: Forbairt took charge over the indigenous industry development and the Irish Science and Technology Board (Eolas), and IDA renamed as IDA-Ireland was given the mandate over the MNCs and

FDI-related activities. In addition, on top of these two agencies a strategic, coordination, and advisory agency – Forfas – was created. In 1998, the reshuffling was finished with Forbairt merged with the Irish Trade Board and parts of FAS (the training agency) creating one agency with capabilities and responsibilities over promoting the Irish owned industry in Ireland and abroad. The merged agency was renamed Enterprise-Ireland.

These agencies, especially in the 1980s with the indigenous looking Enterprise Development Program and the FDI oriented International Traded Services of the IDA, were not focused on the IT sector in particular or on NTBFs promotion in general, but on promoting any kind of entrepreneurial activity in Ireland.³³ However, processes directly related both to state activities and to the activities of private entrepreneurs, coupled with changes in global demand for IT, propelled the software sector as the first sector in which indigenous companies achieved worldwide success. This success in turn refocused most of the attention of the newly created state agencies on the IT sector, enhancing and spurring its continuous growth since the mid 1990s.³⁴

Facing the crisis of the 1980s, the IDA realized that its sole focus on industrial manufacturing MNCs activities was not enough. Therefore, it started to promote the traded services industry, created a specific program to achieve that goal -- the International Traded Services program -- and started to focus its attention on the Irish High Education system. Interestingly the head of this program was also the head of the

³³ Interviews with Declan Murphy (3/10/2001), and Dan Flinters (2/5/2002).

³⁴ In the same vein that produced a cottage industry of books and research that explained the inability of Ireland to achieve economic success in the first half of the 1990s, there is now a flourishing cottage industry of books that explain the rise of the 'Celtic Tiger.' Some examples are: Sweeny, P. (1999). The Celtic Tiger: Ireland's Continuing Economic Miracle. Dublin, Oak Tree Press. Padraic White, the IDA's CEO in the period 1991 to 2000, and Ray MacSharry, the Minister of Finance at the time, present a different version of the story in, MacSharry, R. and P. White (2001). The Making of the Celtic Tiger: The Inside Story of Ireland's Boom Economy. Dublin, Mercier Press. For a refreshing book in that theme that has a very critical view of the Tiger phenomenon, see O'Hearn, D. (1998). Inside the Celtic Tiger: The Irish Economy and the Asian Model. London, Pluto Press.

Enterprise Development Program focusing on the indigenous industry. The IDA pushed for and succeeded in getting incentives, approval, and recognition for a rainbow of traded-services industries, from English-Language-Schools, to software, finance, and film. These idea in turn created the institutional framework in which service industry firms, before looked upon unfavorably, gained in reputation and legitimization. In addition, major software companies opened subsidiaries in Ireland, and a consensus evolved that the future of Irish industry does not rely solely on the manufacturing sector. In another interesting turn of events starting in the second half of the 1980s, the government, employers (including the MNCs), and the labor unions started a continuing series of neo-corporatist wage agreements. While these agreements have little or no effect in the indigenous software sector which is not unionized, it is interesting to note that the macro-economic environment in Ireland was stabilized with a renewed neo-corporatist regime at the time when these agreements and union membership density were declining in importance in general and especially in Israel.³⁵

In the end of the 1980s, software was already recognized as a leading sector. More importantly, unlike other sectors, in software the indigenous industry was already well developed and organized. The ICSA (currently the ISA – Irish Software Association) was a strong politically involved industry association at the time. In 1992, after the demise of the first ill-constructed state unit solely devoted to software, the NSC (National Software Center), the ISA successfully promoted the creation of the National Software Directorate (the NSD). In 1991 the NSD was established within the IDA, to help the software industry (O’Riain 1999). Barry Murphy, then a longtime manager in the

³⁵ For more on the Irish neo-corporatist agreements, see Hardiman, N. (2000). Social Partnership, Wage Bargaining, and Growth. From Bust to Boom. B. Nolan, P. J. O’Connell and C. T. Whelan. Dublin, Institute of Public Administration.

indigenous industry and a member of the board of ICISA and now the CEO of Openet Telecommunication, became its first director. Throughout the years the NSD became crucial on three fronts. It was the first organization to find the size and scope of the software industry in Ireland, finding it in the words of Barry Murphy, “to have more companies than anyone thought at the time” (interview with Barry Murphy, 11/6/2000). Following that initiative, the NSD became the main center devoted to collecting, processing and publishing data on the software industry. Secondly, the NSD became the main promoter of the movement toward the products-development business model and away from the consulting business model, which was prominent model at the time. Last but not least, using an EU grant the NSD can truthfully claim to be one of the main initiators of the high-tech-oriented Venture Capital industry in Ireland.

These state policies, however, did not occur in a socio-economic vacuum, but followed the success of the Irish software industry. By the 1990s, the industry has notably grown and apart from being well organized, a growing number of product-oriented companies attained global success. For the first time, Irish software companies managed to successfully cross the Atlantic and thrive in the American market. The most important of these companies were Smartforce, Iona, and Aldiscon. By 1994-95, the time of the restructuring of the development agencies and the NSD initiative to develop a high-tech oriented VC industry, Smartforce became the first Irish software company to become public on NASDAQ, Iona secured major partnerships with Sun, Motorola, and Boeing, and by 1995 Aldiscon was the market leader in the new mobile phone technology of SMS (Short Text Messages).³⁶ In short, by the time the industrial policy restructuring process

³⁶ Thus, it is not that surprising that Aldiscon was the first company to secure major investment from the EI sponsored ICC software fund in 1996. In 1997, in the middle of an IPO process, Aldiscon was sold to

had begun in 1994, the indigenous software industry was already established as the leading and most successful export-oriented sector in Ireland.³⁷

The first government initiative to create a VC industry in Ireland was not at all aimed at the high-tech sector. In 1994, realizing the financial institutions in Ireland were overly conservative and were unwilling to grant working and growing capital to new enterprises in any industry, the government used a policy of veiled threats to persuade the big pension funds to make available up to £100 million Irish, to Venture Capital very broadly defined. (Unlike the US, in Europe almost any capital involved in the growing or the restructuring of a business falls into the rubric of Venture Capital). Using this finance, three VC funds were established: Delta, Act, and ICC. The three invested most of the funds in later-stage development of businesses, generally in old economy companies. In 1995, NSD initiated the first attempt to spur a high-technology oriented VC industry. The NSD VC initiative, using EU money from the Operational Program for Industrial Development 1994-1999, distributed 43.9 million euros to establish 16 funds (only 15 actually started operation) under a 50% scheme in which half of the fund's finance was granted by the state and the other half was raised in the private market. The state position in all these funds was that of a regular general partner. The first fund to be established was the ICC software fund I. It started operation in 1996 and Maurice McHenry, an old NSD and the IDA's Enterprise Development Program hand, relocated from the NSD to become the fund's manager. Beside one large and recent VC fund (Cross Atlantic) and few semi-institutionalized funds of successful entrepreneurs (Oyster and Island are the

Logica for £90 million in cash and is now the division that generates most of the revenues and profits for Logica-Aldiscon.

³⁷ As a matter of fact the software industry was at the time the only successful indigenous sector in Irish history apart from agriculture and tourism.

two prominent ones), all the VC funds operating in Ireland were created as part of the NSD initiative. In 2002 Enterprise-Ireland announced another VC initiative, this time more regionally and sectorally-oriented and funded fully by the Irish government. Under this new initiative the Irish government will distribute 95 million euros to ten funds, most of which are new funds of the same management companies from the first initiative, with the hope of stimulating the commitment of a total of 500 million euros to these funds' management.³⁸

The VC initiatives of the Irish government through Enterprise-Ireland and the NSD bore some fruit. Starting in 1999, Irish entrepreneurs could reasonably expect to be able to raise enough capital to enable them to start NTBFs focusing solely on new product development, without the need to devolve in consulting to secure working capital. However, as of 2002, especially in comparison to Israel, the Irish VC industry is smaller, less professional, and still intimately linked to established Irish financial institutions. Moreover, the Irish VC industry is more isolated than the Israeli one with the sources of its financing and its connections concentrated in Ireland and Europe. Thus, especially in the software industry where the US is the main market, the VC industry in Ireland is still lacking. However, it might be that some of these features, principally the close connection with the local institutional investors, and the fact that Ireland possesses very developed institutional pension funds, made it very attractive to Irish firms to double-list on both the NASDAQ and the Dublin (or another European) Stock Exchanges, unlike their Israeli counterparts. This double-listing option is one that all the

³⁸ Interview with Denis Marnane 3/7/2002. For more information on the distribution of the first EI VC initiative, see EI (2000). 2000 Report: Seed and Venture Capital Measure of the Operational Program 1994-1999. Dublin, Enterprise-Ireland.

Irish IT companies listed on NASDAQ followed, and it probably diminishes the need to transfer more and more activities to the US.³⁹

Enterprise-Ireland had been also intensifying its own grant giving mechanism. Since 1994, Enterprise-Ireland directly gives companies an annual average of £16 million Irish. However, the grant-giving mechanisms of Enterprise-Ireland highlight the different underlying objectives of the Israeli and Irish industrial policies, and intensify the main obstacle that still exists for many Irish entrepreneurs -- the acute lack of very early and early stage financing for NTBFs. EI financial aid packages for new companies consist of both a hodgepodge of grants, some of which are the remnants of older grant schemes mixed with some new ones, and equity-based investment. As a consequence of the latter and EI's wish to avoid a situation in which a government agency determines the market capitalization evaluation of a private company, the firms that seek EI aid must find private market investors that would resolve the evaluation process. Only then would EI join the investment round on the same valuation basis. This process, in effect, makes it impossible for most early stage IT start-ups to get sufficient financial aid packages from the state. As early stage investment is the riskier with the uncertainty being the highest, EI investments do almost nothing to solve the most intense market failure inherent in new technology development. In addition, it can be argued that EI financial aid packages, as they are organized now, help VCs to lower their risk more than they help NTBFs to secure larger amounts of capital than they could without this venue. These shortcomings are readily admitted by EI. Accordingly, Enterprise-Ireland's CEO Dan Flinters mused: "I agree with some of what you say, especially with the fact that we are still lacking a

³⁹ In 2001, Israel had acknowledged that problem and changed some of its regulations to make it easier and more attractive to Israeli firms to double-list. However, it remains to be seen how widespread will be the effects of those measures.

good mechanism to finance seed and early stage companies, on which we are working, but considering our goals and resources I think we have the best working scheme” (Interview with Dan Flinter, 2/5/2002). Indeed, if you consider that the goal of EI is not to generate the maximum amount of R&D but to maximize the number of successful indigenous businesses that supply the highest number of jobs for the lowest cost to the taxpayer, EI mechanisms are sufficiently well suited.

Somewhat similarly Israel’s economic history can be divided into three periods. The first period is Israel’s first 25 years in which it continued the very high growth rates achieved by the Jewish settlement since 1922. Immediately after the 1948 war of independence, Israel found itself isolated in a region with vastly larger enemies unwilling to do business with it, and with huge waves of immigration of Jews fleeing or being expelled from Arab countries and of European Holocaust survivors. These waves doubled Israel’s population by 1954 and tripled it by 1963. As of 1948, Israel had one of the highest educated workforces in the world, and while the waves of immigrants from the less developed Arab countries lowered the average level of education, the institutional underpinning of Israel’s education system and its research-oriented third level education system was already well established and enabled Israel to quickly upgrade its workforce. From 1948 to 1973 Israel enjoyed an almost undisturbed fast growth. In the first two decades until 1972, Israel enjoyed an annual growth rate of 9%, with GDP increasing ten fold since independence. Moreover, this remarkable economic feat was done with the state, led by the socialist labor party, firmly committing itself to a full-employment ideology.⁴⁰

⁴⁰ For a good collection of articles that analyze the growth of the Israeli economy, see Ben-Porath, Y., Ed. (1986). The Israeli Economy: Maturing through Crises. Cambridge, MA, Harvard University Press.

However, in 1973, Israel dipped into a major economic crisis that lasted over a decade, a period aptly named “the lost decade.” After the war of 1973, Israel suffered multiple economic crises. Economic growth was almost halted, the balance of payment deficits rose in alarming proportion, and inflation rapidly rose to over 400% annually. Moreover, by 1983 all of Israel’s major banks had confessed to being participants in a scheme of running their own shares in the Tel-Aviv Stock Exchange. In 1983, this scheme became unsustainable and forced the government to nationalize these banks in order to save Israel’s banking system from bankrupting en masse. In the period 1977 to 1985, the first political transfer of power intensified the economic crisis. The right wing Likud won the 1977 elections and implemented a series of untenable expansionary policies coupled with the elimination of barriers on capital transfer and exchange while continuing the pledge for full-employment. In 1985, a rainbow coalition government led a stringent stability plan. The plan worked remarkably well in some areas: inflation was cut to a more manageable rate and continued to stabilize throughout the 1990s and growth rates had picked up from a low of 1.9% to a more reasonable rate.⁴¹ However, since the end of the 1980s unemployment has become a problem, especially in the periphery. Starting in the 1980s and continuing in an escalated rate in the 1990s, another transformation had become apparent, with the high-tech industry quickly growing, whereas the traditional and mixed industries and agriculture lost ground. If by 1988 already 59% of Israel’s industrial exports were high-tech products, by 1998 over 71% of Israel’s industrial exports were high-tech. This transformation became complete when in 2000, according to Israel’s Central Statistics Bureau, the IT industry alone accounted for

⁴¹ For more about the causes of the crisis and the stabilization program, see an article written by the chairman of Israel’s central bank at the time, Bruno, M. (1989). *Israel's Crisis and Economic Reform: A Historical Perspective*. NBER Working Paper Series.

over 70% of GDP growth.⁴² In addition, Israel's corporatist wage agreement regime had been crumbling, with labor-union membership in fast decline and the socialist ideology in fast retreat.⁴³

Descending from this macro economic level, Israel's industrial policy can be broadly divided into four main periods. In the first period from 1948 to 1966, the state followed a protectionist economic policy coupled with an interventionist industrial policy trying to secure three goals: security and regional policy, industrial development, and the building of a private-ownership-based economy. The huge waves of immigration were channeled to newly developed cities located according to security-based logic of Jewish population distribution throughout the country, not on a purely economic basis. The state anchored these new cities around privately owned government-subsidized large-scaled plants. Textile was the one industry in particular to be the focus of this state industrial planning, but parts of the defense industry complex and various other industries were enlisted to these aims. The state, led by the socialist party until 1977, had also (surprisingly to some) used its considerable power to ensure that private ownership of the forces of production became the predominant ownership form in a successful effort to create a vibrant capitalist economy in Israel. In the one time when the federation-of-labor-unions' (Histadrut) industrial conglomerate -- Solel Boneh -- was reckoned to gain too much power, the state moved briskly to break it up and forced the resignation of its manager. The labor-led government did so at a time when the party was controlling the

⁴² See CBS (2001). Development of Information Communication Technology in the Last Decade, Central Bureau of Statistics - Israel.

⁴³ For more about the history of neo-corporatism in Israel, see Shalev, M. (1992). Labour and the Political Economy in Israel. Oxford, Oxford University Press., and Grinberg, L. L. (1991). Split Corporatism in Israel. New York, SUNY.

Histadrut and with the manager being a longtime party member.⁴⁴ The result of these policies was a quasi-private large-scaled plant-based industrial sector, which was deeply dependent on government subsidizes and help, and was actively lobbying for them.

In 1965-7, Israel suffered its first recession, which ended with the 1967 war. The end of the war became a critical point in regard to Israel's science and technology industrial policy, thanks to the unexpected hero of the Israeli IT industry: France's President Charles de Gaulle. Today, after three decades of close alliance with the USA, only a few remember that in the first two decades of its independence Israel's main ally was France. Israel bought almost all of its military equipment including critical systems like fighter-jets and ships from France, and Israeli engineers were working closely with French teams on modification and specific systems R&D for various weapon platforms.⁴⁵

In 1967, de Gaulle officially insulted that Israel did not consult him before the June war, but probably due to reasons of international politics and France's decision to ally itself with the Arab world, de Gaulle declared an immediate military embargo on Israel. That decision resulted in Israel's inability to buy critical weapon systems off the shelf anywhere in the world, (The alliance with the US didn't commence until after the 1973 war and even to this date the US does not allow Israel access to a number of crucial technologies.) The immediate reaction of the Israeli state was to dedicate large sums of money and R&D power into military high technology efforts. A decision was reached

⁴⁴ An interesting study on the first 25 years of industrialization in Israel is David Levi-Faur's. Following the "developmental state" literature, Levi-Faur uses a statist approach and argues that the state, led by the labor party was the main engine of the industrialization project, following an economic-nationalistic ideology that saw private market entrepreneurship as superior to both union and state-owned entrepreneurship, Levi-Faur, D. (2001). The Visible Hand: State Directed Industrialization in Israel. Jerusalem, Yad Ben-Zvi Press (in Hebrew).

⁴⁵ Israel and France conducted many co-development research projects. France and Israel were also crucial for each other's nuclear program, with France licensing the technology developed at the Weizmann Institute for the production of heavy water and helping Israel, in return, to build its nuclear reactor.

that Israel should never again be completely dependent on a foreign power for military platforms. Thus, starting in 1967, Israel's military R&D targets changed from developing niche weapon systems, the most sophisticated of which was radar-guided rockets, to developing its own weapon platforms like tanks, fighter-jets, and ships.

With the decision in the 1980s to stop the development of the latest fighter-jet ("The Lavi") this strategy was officially abandoned. However, Israeli companies still develop tanks, coastguard-ships, and precision guided rocket systems of all kinds (in addition to niche products and communication-related systems). Moreover, the amount of large-scale-system-integrated multi-disciplinary R&D knowledge, capabilities, and, more importantly, management experience, gained by the Israeli high technology industry is almost incomparable to any state of the same size.

At least as important as the complete overhaul of the military R&D that Charles de Gaulle spurred, were the related changes in industrial policy that happened in 1968. Analyzing the recession of 1965-7, the state realized that growing exports necessitated a change in Israel's industrial policy. That realization, coupled with the renewed interest in, and success of, military R&D, led the Prime-Minister Levi Eshkol, who in his former positions as head of the defense and finance ministries, was key in developing both the military and civilian industrialization efforts of Israel, to ask his old friend and one of the key people behind the creation of REFAEL, Professor Ephraim Katchalski-Katzir, to head a special committee on civilian R&D. The Katchalski committee advised the establishment of the Chief Scientist Offices in the main government ministries, the key one of which was in the Ministry of Trade and Industry. The Office of the Chief Scientist in the Ministry of trade and Industry (hereafter: the OCS) was formally established in

1968, but started full-scale operation only in 1973. The OCS defined its objective as fixing market failures in the area of civilian industrial R&D and provided a flat 50% of cost for any industrial R&D project aimed at developing a new exportable product in conditional repayable loans (the loan was payable only if the R&D project turned into a profitable product). These grants were natural in regard to industrial sectors, the main logic behind the OCS being to fix market failures in R&D investment with the explicit assumption that the private entrepreneurs know best what are the most profitable markets to innovate in (Teubal 1983). Thus, in the 1970s these grants helped projects as diverse as bio-medical electronics, computers, geothermal power plants and pre-set printing.

Consequently, at the same time that the 1973-1985 economic crisis was destroying Israel's old political economy, weakening the traditional and mixed industrial branches and the established financial system, the new focus on science-based industrial development and the major investments in the defense industries slowly built the foundation of the new IT industry. In 1972, the first Israeli IT firm listed on the NASDAQ and by the end of the economic crisis in 1985, an IPO on NASDAQ was already a legitimate and well-treaded path for the more successful Israeli high-technology companies. However, the IT sector did not pass through the economic crisis unscathed and with the crushing of the banking system both the Elron group and Scitex were faced with their biggest crises to date. Nevertheless, by that time they were no longer the only IT corporations in Israel.

If in the first period of Israel's industrial policies, science and technology did not play a major role, then the second period from 1968 to 1984 saw a massive upgrade of the defense industries and the first and isolated international success of a few IT

companies. The OCS started its activity in earnest only in 1973 after Yaakov Itzhak (Yatza) was recruited from a similar role in the IDF. After Yatza joined the OCS, the agency quickly developed its activities, taking a very proactive role to the point where the OCS's main problem in that period was the lack of willing entrepreneurs. Another important decision in those times gave the OCS the ability to grant an "approved plant" status to NTBFs, which granted them all the economic incentives and aid given under the 1959 Law for the Encouragement of Capital Investments, the same law used to grant aid to plants in the newly constructed peripheral cities. That linkage became more important in later years when Intel, National Semiconductors, and Tower, applied for aid under its provisions when constructing fabrication plants.⁴⁶

Following the 1973 war and President Nixon's visit to Israel, the Bi-national Industrial R&D foundation (BIRD) was approved in 1975 and start working on fostering and financing cooperation between Israeli and US companies. Its mode of operation was funding projects in which the R&D part was done in Israel and the marketing in the US. Like the OCS, Bird did not start its operation until its second executive director, Ed Mlavsky, arrived. Nevertheless, in a short period after his arrival, Bird became crucial not only in sponsoring and helping Israeli NTBFs, but as an organization that ensured these NTBFs a critical venue into what became their main market, the US. BIRD had also become crucial in the later part of this period and throughout the 1980s and 1990s in enticing American MNCs to open an R&D subsidiary in Israel.

The third period can be said to start with the approval of the R&D law in 1984 and the recognition of software as an industrial branch in 1985. Until that time the OCS,

⁴⁶ While probably critical in securing the construction of the Fabs in Israel, the overall economic effects of the capital investment law were probably negative even in the 1990s, see Bregman, A., M. Fuss, et al. (1998). The Effects of Capital Subsidization on Israeli Industry. NBER Working Paper Series.

not anchored in law, fought chronic budgetary battles, and also, following political lobbying by Elscient that ended with a tax-sanction law (aptly nicknamed the Elscient law), question marks over the OCS's capture by the industry tarnished its image.

The period from 1984 until the beginning of the 1990s, can be seen as the reconstruction period of the institutional basis of Israel's political-economy. The old centralized traditional and mix branches of industry quickly, apart from rare exceptions, lost ground, the ideology of full employment was no longer held to, and the state-owned defense industry companies started their decline with the cancellation of the Lavi (fighter-jet) project and the realization that the state is unable to continue to finance them to such a high degree.⁴⁷ However, the OCS, under the management of Yigal Erlich and under the new R&D law, was quickly expending its activities together with BIRD's; the Elscient law was revoked in 1985; and, sanctioned by the R&D law, the OCS regained its independence and public image as a professional agency. In addition, private IT entrepreneurs became not only more active and successful, but also more common. High technology entrepreneurship had become a legitimate option, and the lack of willing entrepreneurs was no longer an acute obstacle to the development of the industry. Furthermore, the first internationally successful software product companies appeared, most of them still using a model of financing based solely on private capital and revenue-based growth as they could not apply for OCS grants.

1989 is the year that marks the real beginning of the latest period. The USSR started its democratization and break-up process and Jews, who had been unable to immigrate until that time, started the last big immigration wave into Israel. Unlike the

⁴⁷ The transformation was not that apparent at the time and many commentators thought it had failed; for example, see Teubal, M. (1993). *The Innovation System of Israel: Description, Performance, and Outstanding Issues*. National Innovation Systems. R. R. Nelson. Oxford, Oxford University Press.

former waves of immigration the approach toward this wave was dramatically different: gone were the days when the government built cities in the periphery, forced new immigrants to settle them, and using a mix of coercion and economic incentives, lured private entrepreneurs to build large manufacturing plants around them. Moreover, this wave was seen as bringing with it the best and the brightest technologically educated workforce from the USSR, and together with the thousands of engineers who were made redundant by the defense industry, the question of tapping this body of knowledge sprang to the top of the political agenda. In addition, the Israeli government secured the United State's help to raise a \$10 billion in bonds to finance the settlement of so many immigrants (20% of total population in less than one decade). Thus, with the old political-economy institutional system of Israel mostly broken, knowing it had to act, viewing this wave as scientifically and technological savvy, sharing a wide consensus that high-technology industrialization offered the only viable economic future, and having sufficient finance, the political and bureaucratic apparatus of the Israeli state was very open to new initiatives led by the OCS which were aimed at solving exactly these problems.⁴⁸

Starting in 1991 the OCS, led by Yigal Erlich, initiated and implemented four new programs, all aimed at a specific goal, the enhancement of the formation, survival and success rates, and R&D capabilities of NTBFs. Interestingly, while the last three programs, The Technological Incubators, Yozma, and Magnet, started operation between 1992 and 1995, they were all planned and approved in 1991, the year that can be seen as

⁴⁸ For more about the present R&D policy and schemes, see Trajtenberg, M. (2000). R&D Policy in Israel: An Overview and Reassessment. NBER Working Paper Series.

the high point of the latest political window of opportunity.⁴⁹ In 1991, two new programs started operations, each aimed to solve a perceived market failure in different NTBFs' stages of development. The Inbal program was the first serious government attempt to induce the creation of a private VC industry in Israel, long viewed as a critical missing link to enable Israeli NTBFs to succeed in the market after the end of their product development phase. Until that point only two VC institutions were present in Israel: Tolkowsky and Adler's Atena VC fund, a limited partnership fund based on the American model established in 1985, and Star, a private equity fund established in 1989 which became a Yozma fund after 1993. The Inbal program was an attempt to foster publicly traded VC companies by creating a government insurance company ("Inbal") that guaranteed new VC funds traded on the Tel Aviv Stock Exchange a minimum value, calculated as 70% of the value of the public issue, and issued certain restriction on the investments of insured funds. Four funds were initially established but no follow-up activity was spurred and the funds valuation on the stock exchange tended to be low, with the funds getting the same valuation as holding companies. The funds found that they dealt with excessive bureaucracy and finally attempted to and succeeded in leaving the program. Today all the fund are under the management of one holding company – Green Technology Holding (Avnimelech and Teubal 2002).

In the same year, 1991, the OCS had also initiated the Technological Incubators Program. Initially the program was presented as a solution to two problems: first, the inexperience and inability of many technically-oriented or scientific entrepreneurs to become successful commercial entrepreneurs and find very early stage financing for their ideas; and second, the difficulty of many of the Russian technologically skilled new-

⁴⁹ Interview with Yigal Erlich 8/21/2000.

immigrants to find jobs and successfully integrate in a capitalist market. The idea was to open a network of technological incubators that would help entrepreneurs in the very early stage of transforming an immature idea into a commercial reality, by giving them most of the financing and large amount of professional business and management help. The goal has been that after two years when they graduate from the program, the companies will be mature enough to secure private VC financing. In the first few years of the program a certain percentage of the workers in each company needed to be new immigrants from the former USSR, but that condition was later dropped.⁵⁰ In a similar fashion to the other OCS programs, proposals for the incubation had to come from the market and teams consisting of academic institutes, municipalities, and businesses that passed through a quality assurance process were given management over almost equally well geographically distributed incubators throughout Israel. The incubators need to find and recruit entrepreneurs, test their business plan, and then send these as application to the OCS, each accepted application is granted up to 85% of financing (as of 2002, around \$400,000) for the first two years of operation.

By the end of 2000, 24 incubators were in operation and 883 companies had been part of the program. Of these, 240 were still in the incubation centers and 643 had graduated; of these that graduated 53% have continued operation and 47% were closed down. The total private VC financing that the graduating companies managed to secure was in excess of \$525 million. In addition, one company, Compugen, is already publicly listed on the NASDAQ and is considered to be one of the leaders in its niche market. It is also reasonable to assume that more IPOs will follow after the NASDAQ will overcome its

⁵⁰ The contribution of the last wave of Russian immigration to the Israeli IT industry remains an open question. At best one or two of the 152 going through an IPO on NASDAQ in the last 13 years has had new Russian immigrants in the founding team.

present crisis, since ten or more incubators' companies secured major investment rounds (more than \$10 million) from leading American investment banks and underwriters. In a similar fashion to the OCS other programs until 2001, when more specialized incubators programs were approved, while some of the incubators became more specialized in time overall the technological incubators network did not pick any sectors, and R&D projects from all branches of the industry were admitted. As a result, the distribution of projects by industry until 2000 was as follows: electronics and communication 11%, software 11%, medical 18%, chemistry and materials 20%, biotechnology 20% and others 23%.⁵¹

In addition, two of the most important impacts of the program have yet to be considered and tested properly. First is the major impact that the program had on changing the preferences of technologically and scientifically educated personnel to willingly become entrepreneurs, an effect that might prove catalytic. Second, as the present technology crisis shows, the program is important in granting a certain baseline of NTBFs formation rate, which is immune to both the extremely volatile behavior of the VC industry in regard to the number and amounts of investment, and the herd mentality and fashion-like behavior of VCs in their sectoral investment criteria. For a state like Israel that is economically depended on the high technology sector, securing this baseline is of critical priority.

The technological incubation program had been the target of attacks from both ends, some argue that it is a too costly program of job creation and that the state had poured too much resources into it without any apparent successes, others that the way in which the program is constructed it grant too little financing for its companies and forces them, long before they are ready, into a vicious cycle of finance raising, saddled with a

⁵¹ Interview with Rina Pridor (2/8/2000), Trajtenberg, Ibid, and the incubation program web site

stigma of an “incubation” accordingly of not fully mature company. However, while the incubation program is far from being an indisputable success story, until proper research and few more years will pass, it is too early to decide whether the program had been accomplishing what it aimed for.

In the same years that the OCS was busily developing and implementing new programs, new developments in the private industry had changed the IT industrial landscape in Israel. If until 1990 the total number of IPOs of Israeli firms on NASDAQ was ten, in 1991 alone three companies had gone through IPOs and in 1992 another nine. Moreover, unlike the low valuation IPOs in the past, some of these IPOs were done in large enough market capitalization for these firms to have been a respectable exit for an American VC at the time. In addition, 1991 was also the year in which the first pure software companies had gone public on NASDAQ. In 1991-1992 it became apparent that the Israeli IT industry had passed into a larger and more mature phase of operation.

In 1992, learning from the failure of Inbal, the OCS initiated another program aimed to induce the creation of a vibrant VC industry in Israel – Yozma. This time and in almost a complete opposition to its behavior in the past the OCS, again led by the Yigal Erlich as the Chief Scientist, decided that the necessary skills and knowledge did not exist in Israel, and that in order to succeed an Israeli industry would need strong networks with foreign financial markets to secure its capital and not with the Tel Aviv Stock exchange. As a result, Yozma was created as a government VC fund of \$100 million that had two functions. The first was to invest \$8 million, which would be 40% or less of the capital of private limited partnership VC funds. In order to get this financing the funds had to secure investment and partnership from at least one established foreign financial

institution and from at least one local one. Each fund was also offered a call option on the government share at cost plus interest for five years, and thus if the fund management thought that its investments are going to succeed they could buy the government out cheaply. Yozma invested \$80 million in ten funds: five were established in 1993, one in 1994, two in 1995, and one in 1996, and all but one opted to use the call option.

Secondly, as well as investing in those funds Yozma had also started its own VC fund, Yozma I, with \$20 million under management and with Yigal Erlich, who left the OCS to head the Yozma program as its CEO. Private businessman later bought the Yozma fund.⁵² Unlike Inbal, Yozma had turned into an acclaimed success and a model for VC-aimed policy worldwide. The establishment of the 11 Yozma funds, the growing success of Israeli companies on NASDAQ, the fact that the Israeli landscape at the time had many high quality NTBFs looking for capital, coupled with an almost perfect timing in the beginning of the greatest growth in demand for IT and the related financial boom that the world had known, resulted in excellent returns for the Yozma funds, and in a quick pouring of capital to the Israeli VC industry (see graph 5). Today the Israeli VC industry consists of over 70 funds with many of the top US and global funds opening operations in Israel and with total capital under management of approximately \$5 billion. Moreover, the success of Israeli companies in the US in the 1990s had transformed the institutional setting and for the last few years many Israeli companies have raised capital mainly from established foreign VCs and financial institutions in their later (and sometime in their earlier) development stages.⁵³

⁵² Interview with Yigal Erlich 8/21/2000.

⁵³ For more about the development of the VC industry in Israel, see Avnimelech, G. and M. Teubal (2002). Venture Capital - Start Up Co-Evolution and the Emergence and Development of Israel's New High Technology Cluster. Unpublished Manuscript.

The last initiative designed by the OCS in 1991, MAGNET, also started operations in 1992, systemized its activities in 1994, and added another smaller projects sponsorship path in 2001. Unlike the other OCS programs, MAGNET, which stands for Generic Non Competitive R&D, aims to solve two problems relating to later stages of development and maintenance of long-term competitive advantage of Israeli NTBFs. First, is the fact that in Israel a large number of companies work in the same technological space, all of them too small to be able to compete on the basis of, or advance, cutting edge *infra-structural* research activities that are crucial for their ability to sustain competitive advantage against the bigger MNCs. Second, is the underutilization of the academic research done in Israel. Like the rest of the OCS programs, MAGNET grants aid to programs initiated from the private industry. However, as MAGNET aims to create a consortium to develop generic technologies, a MAGNET consortium is created for a period of up to three years and all IP outputs are shared between the consortium members, which also agree to license this IP to local companies at a cost that does not reflect monopoly status. A consortium, which consist of at least few companies and one research/academic institution applies in a competitive fashion to MAGNET and is granted, if approved, financing to the level of 66% of cost for the agreed period. MAGNET financial aid is given in grants only with no need to repay. The same process applies for a consortium of users with an aim of distribution and implementation of generic technology. Over the years many research consortia in highly heterogenic technological fields have been operating; some examples are: ground stations for satellite communication, magnesium technologies, multimedia on-line service, DNA markers, advanced electronic packaging, and ultra concentrated solar energy applications.

The demand of the industry and academia to the research consortia program has been overwhelming and as early as 1996 MAGNET become the second largest program of the OCS. In the 2001 fiscal year existing MAGNET research consortia got financial aid in the sum of \$64 million from the OCS. The users' organization program has been less successful with only one serious user organization in advance technologies in electronics ever making progress.

In short, the industrial development agencies of the Israeli state proved very able and flexible in advancing the overarching goal of the creation of science based industry in Israel, and the advancement of NTBFs as the cornerstone form of Israeli industry. At many critical points the state either spurred the creation of the local industry, initiated catalytic programs that induced institutional transformation and fast growth or created the needed service industry. Moreover, without doubt the OCS was crucial in sustaining and enhancing the R&D capabilities and successes of the Israeli IT industry.

However, at one focal point, the policy of the Israeli government had been either neglecting or disastrous. In 1968, the government could rely on a very strong academic research and innovation system, and one can interpret, with more than a grain of truth, the development process of Israel's IT industry is as a successful effort to expand that capability for research throughout the innovation system.⁵⁴ Moreover, between the 1960 and 1981 the Israeli third education system had accomplished a remarkable feat, at 257% the growth rate in the number of scientists and engineers in

⁵⁴ Israel's universities had managed to keep the top spot of most papers published to GDP ratio from 1968, however, growth in the annual number of publication had been slowed or halted and in some disciplines declined, see NSB (2000). Science and Engineering Indicators 2000, National Science Board. Figures 6-55 to 6-61. On the growth rates of Israel's international patenting, a good proxy for industrial R&D, in the period 1968-1997, see Trajtenberg, M. (2001). "Innovation in Israel 1968-1997: a comparative analysis using patent data." *Research Policy* 30(3): 363-389.

industry was probably one of the world's highest, more than twice the rate of Japan in the same years (Halperin, 1986). Nevertheless, at the end of 2001 the Israeli education system seems to pass through three decades of deteriorating quality and standards in the elementary and secondary system.⁵⁵ Furthermore, in the end of the 1980s the state prompted the creation of regional and private colleges that enables a larger percentage of the population to attain a reasonable first-degree high education, an act undoubtedly needed; on the other hand, state aid for Academic and basic science research in Israel stayed in more or less the same real terms for the last three decades.⁵⁶ Moreover, if in the first two decades of Israel's independence admiration for pure science might have been too strong, in the last two decades some prominent politician, especially from the right, sees the universities as an opposing elite needed to be broken. While it might be true that

⁵⁵ Longitudinal international comparative studies of elementary and secondary student achievements are hard to get by, however, The TIMSS study of 1995 and the Repeat-TIMSS of 1999, the biggest over international studies conducted, might give us a glimpse. In the 1995 TIMSS science and mathematics assessments for students in both the 4th and 8th grade done, Israel rated below average for a developed country with Israeli students scoring well below their Irish counterparts in both science and mathematics in both grades, and below the US students in all but 8th grade mathematics. Israeli 4th grade students were rated 21st out of 26 in science and 14th out of 26 in math. Israeli 8th grade students were rated 23rd out of 41 in science and 22nd out of 41 in math. The countries with the most similar profile to Israel's were Latvia in 4th grade scores and Thailand in 8th grade scores. In the 1999 TIMSS study on 8th grade students Israeli and Thai students had the sharpest decrease in their average scores in both mathematics and science. Israeli student's average in science was now lower than the international average and Israeli students were rated 26 of 39, in mathematics Israeli student average was now significantly lower than the international average and Israeli students were rated 29 out of 39. The only caveat might be that in 1995 researchers in Israel used an unapproved sampling method in, so it might be that the situation in 1995 was already as bad as the situation in 1999. Sources: Beaton, A., M. Martin, et al. (1996). *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA, Boston College, TIMSS International Study Center, Mullis, I., M. Martin, et al. (1997). *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA, Boston College, TIMSS International Study Center, Martin, M., I. Mullis, et al. (2000). *TIMSS 1999 International Science Report*. Chestnut Hill, MA, Boston College: The International Study Center, Mullis, I., M. Martin, et al. (2000). *TIMSS 1999 International Mathematics Report*. Chestnut Hill, MA, Boston College: The International Study Center.

⁵⁶ It is indeed true that on the aggregate Israel's expenditure on R&D is one of the highest in the world standing as it is on 4% of GDP. However, as soon as it is disaggregated, some serious anomalies appear. For example, 78% of total research funds in 1998 were channeled to telecommunication technologies (higher than Finland's even with most of Nokia's R&D done in Finland), and the fact that funding channeled to scientific research even under very generous assumptions is less than the OECD average, see Ben-Tur, A. (2002). *Investment in Civilian R&D in Israel: Data as a Basis for Discussion in the Purpose of Developing a National Policy*. *STE Working Papers Series*. Technion - Samuel Neaman Institute.

changes are needed in the system, attention is given mostly to undergraduate education, and no serious analysis of the goals and needs of Israel's R&D basis had been done. Moreover, with the diminishing funds for defense sponsored R&D, finance for basic research in many technologies that proved crucial for the Israeli IT industry is declining, and while the colleges have an important role as educational institutions it seems as if their present and future development further divert academic funding from research. Lastly, no discussion on the future of scientific research in Israel is planned to take place in the near and mid-term future. Thus, two of the basic building blocks of Israel's R&D apparatus: a high quality K12 education system and the research capabilities of the high education system, have not been well attended in the last two decades.

Conclusion

This paper had shown that the IT industries of both Israel and Ireland had grown in unprecedented terms in the 1990s. As part of that growth the business, financial, and industrial environment in the two countries had been transformed. However, the two industries followed a very different development path, and the two institutional systems that evolved lend different strengths and weaknesses to NTBFs originating from the two states.

In Israel, the state, building on a strong academic institutions that already possessed strong research capabilities, on a nascent if growing "science base" industry, on a large high-technology-oriented defense industry, and faced with a critical security threat, developed a consensus of "science-based" industry as a solution for Israel's economic future. The concept around which the Israeli industry developed saw industrial

R&D activities as the focal point of any economic growth; with the state role being fixing the broadly defined market failures associated with R&D in a proactive way. The state in that view had no ability to select and choose sectors and winners, but had a critical view in assisting those who want to become winners in doing so.

This concept had a pronounced impact and business development in Israel. Due to the fact that capital for business development was almost impossible to secure, the importance of the financial options offered by the OCS and later by Bird, cannot be underestimated. Starting in the end of the 1960 to the 1990s the most prominent opportunity for any Israeli wishing to become entrepreneur was to develop concept for technology-based product and build a company around it. Thus, for over thirty years entrepreneurs-to-be were prompted to think and see their business as new-technology-product-development-company. The Israeli IT industry development and growth was spurred by the OCS and its various programs in the same time that they also primed and trained these companies to view the R&D product development process as the heart of their activities. In addition following the French embargo, through the establishment of the IPO on NASDAQ path by Elscient, strengthened by the activities of the Bird foundation, and cemented in the development of the 1990s, Israel's IT industry became intimately connected with the American market. With the growing success of Israeli firms in the United States and the rush of American capital to the Israeli IT industry in the 1990s, the pull of the American market on Israeli NTBFs became more pronounced. With not only their customers, but also a growing share of their investors and shareholders being American, and with the Israeli market becoming less important, more and more Israeli companies feel the need to become as American as they can. Hence, at

the same time that Israel attained, with the IT industry, its largest industrial success, the development path which the state itself pushed for, puts into question how much of the fruits of that growth can Israel enjoy in a sustainable way. The recent crisis with its affect on the VC industry and accordingly the reaffirmed importance of the OCS's programs might diminish the urgency of answering those questions, but not the long-term importance of it.

Ireland followed a very different path. When Ireland decided to implement the new economic policy in 1958 and poised job creation as its most important goal. The Irish educational system and scientific capabilities were not something the state could build upon, and while research was important to the universities, most of them saw their main role in teaching. Further, no other part of the Irish innovation system was geared toward research, and the percentage of Irish who did not finish secondary education was over 67%. The Irish state moved, therefore, toward an industrial policy that viewed export oriented manufacturing as the way forward. Quickly thereafter an emphasis on FDI led manufacturing industrialization won a consensus as the way forward, that consensus was strengthen after Ireland joined the EU and severed its ties with the English Pound. In the 1980s, after suffering another economic crisis the focus on manufacturing plants was changed and traded services industries and IT came to the fore. Starting in the 1960s the education system was expended out of a supply side industrial policy viewed as a necessary tool to train the required high-skilled labor, in the 1980s as part of the refocusing of Ireland industrial policy the technical regional colleges became more intimately linked to the needs of the heavily MNCs controlled industry.

However, as part of those transformations a new generation of Irish entrepreneurs came to the fore. This generation, better educated than most of its EU counterparts and certainly better educated than any generation of Irish in the past, not only managed to build IT firms, especially in the software sector, and grow them to succeed in international markets; but was also intimately connected to these global markets being exposed to, and part of, the leading MNCs. Thus, at the same time political pressure intensified to change the Irish industrial policy from its overall focus on FDI-based industrialization, the Irish software industry with some help of the state, had already offered a promising alternative for the way forward. In the second half of the 1990s this transformation was completed in the state apparatus with the establishment of EI and Forfas, with the education system seemingly following a similar path: after a change to the worse in research funding the 1980s, the Irish state started two new large-scale initiatives to build advanced research capabilities in Irish universities: PLRI and Science Foundation Ireland.

This history had tremendous effect on the development of Irish companies. First, overwhelmingly Irish IT companies had been operating in the software sector where it is cheaper and easier to manage enough R&D activities to develop a product on the basis of service and consulting revenues. The legitimacy of this service and consulting revenue-based growth was such that even the most successful Irish hardware company, Parthus, was built around a model of service-oriented design-house.

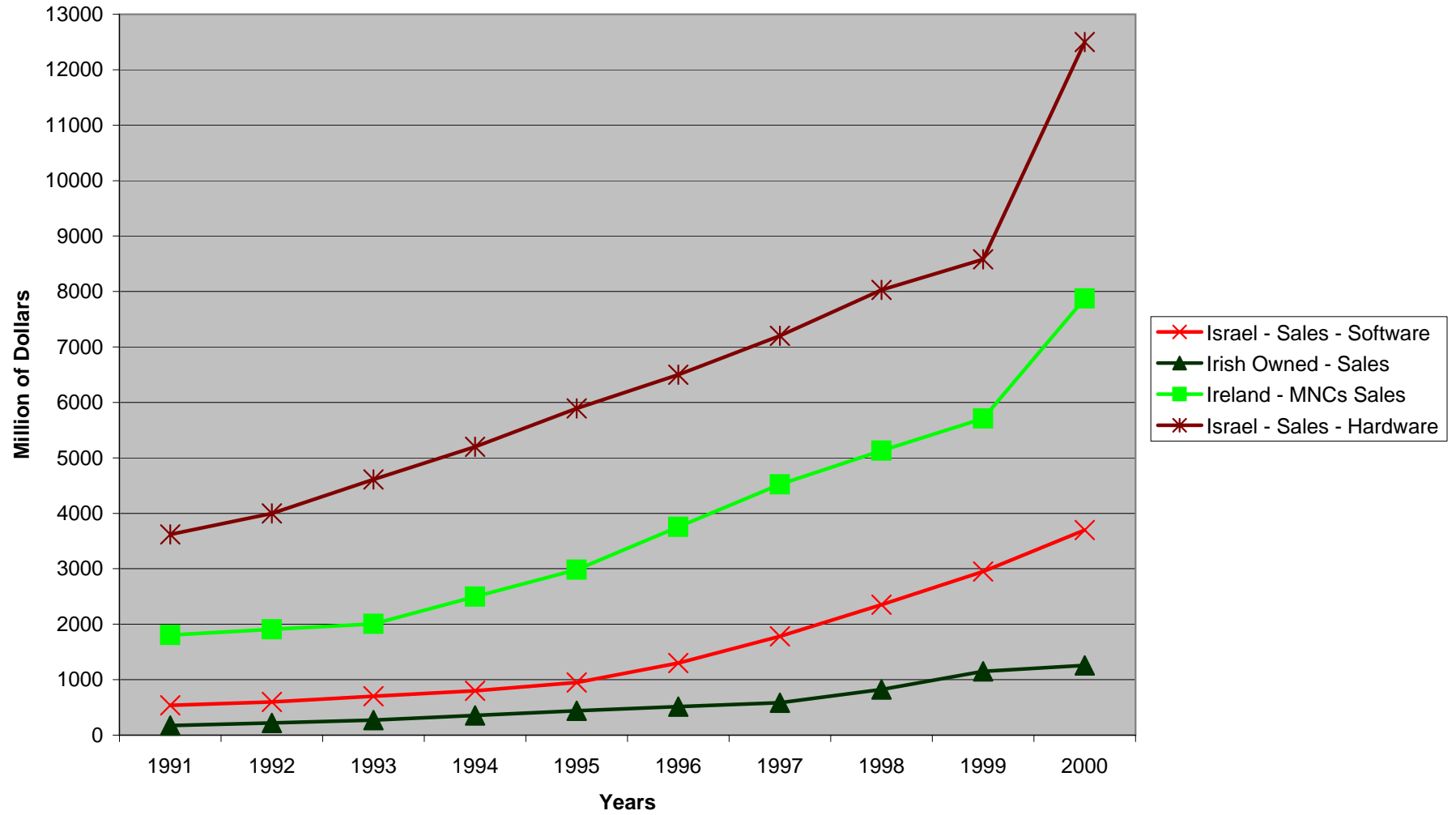
Unlike their Israeli counterparts most of the Irish IT companies are not based on intensive R&D based products, and a larger percentage of founders and promoters of Irish IT companies do not have technological background. Although the number is still

small it is a telling anecdote that out of the seven Irish IT firms listed on the NASDAQ in only two all of the founders come from technological background, with one of these, Datalex, created after the IDA convinced a Scot, Niel Wilson, to come to Ireland to open the company in 1985. Moreover, out of the seven only one, Riverdeep, did not use consulting and service business model in its growth phase and that had to do more than anything else to the other unique fact about Riverdeep, it being the only Irish IT company publicly listed in NASDAQ founded and backed by an entrepreneur who already had one of his companies listed.

Indeed, the growing VC industry might change this model of revenue and consulting-based growth. However, the fact that seed and very early stage financing are still very hard to secure, and that the VC industry is still very conservative, forces many companies to secure some revenue-stream before commencement of product R&D activities. In short, while the state assisted Irish companies in their growth, state aid was neither suffice for, nor oriented toward the creation of product-based IT companies. The development of the industry, and its ultimate growth, had more to do with the success of Irish companies to use revenue-based growth model, and with the Irish market for software being as small as it was until 1998, on their success in securing customers outside Ireland. Unlike Israel, the creation and development of the indigenous IT industry had not become a goal of the Irish industrial policy, until after the industry had already proven its capability to succeed. However, it might as well be that these seemingly weaknesses of the Irish IT sector: the smaller and more locally linked VC industry, the greater reliance on revenue based growth that had been forcing Irish companies to look for customers in Europe first, coupled with the more developed

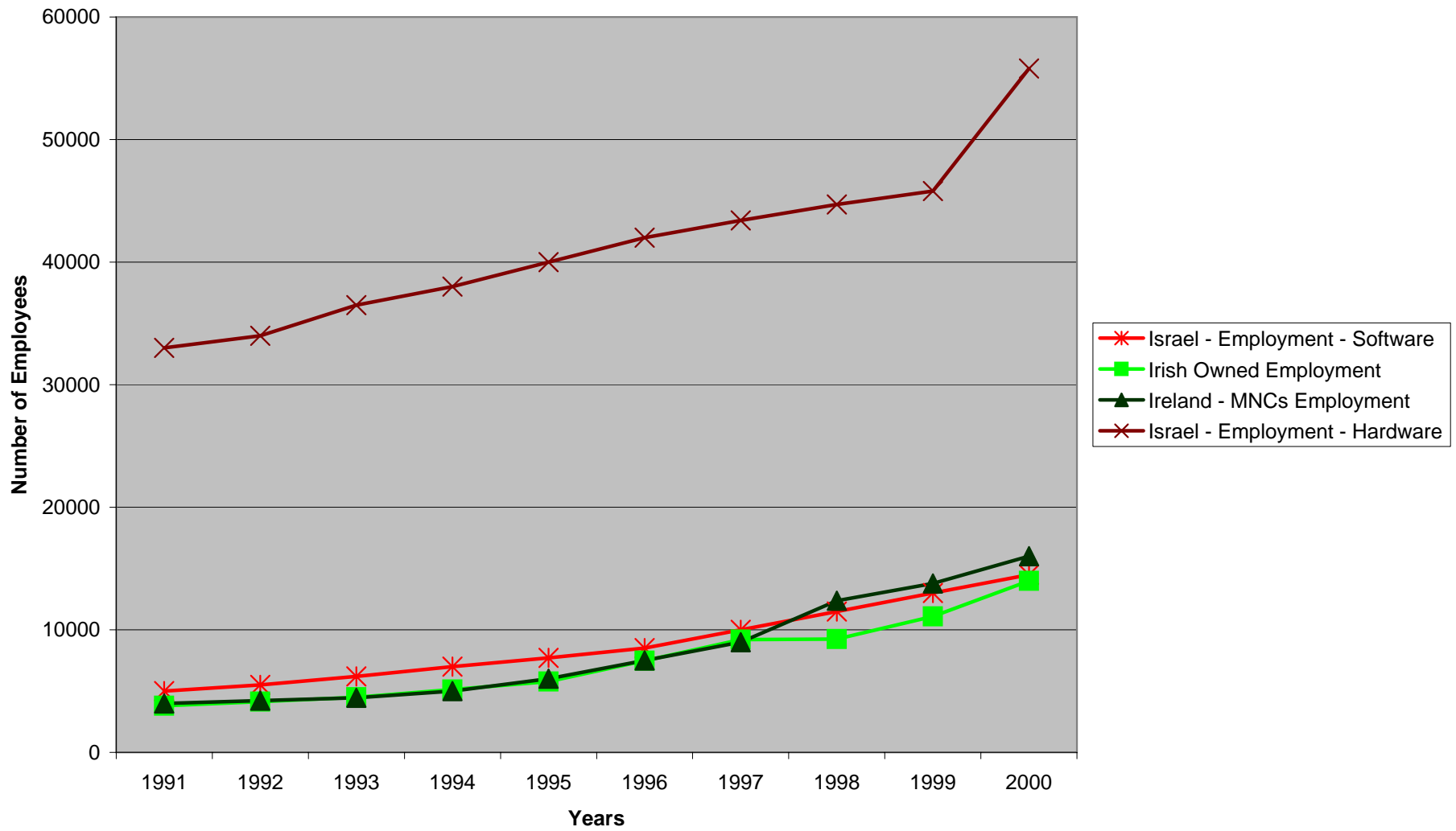
financial markets at home, had left the Irish IT industry much more Irish, with a larger percentage of the fruits of its growth recouped at home.

Total Sales Ireland and Israel



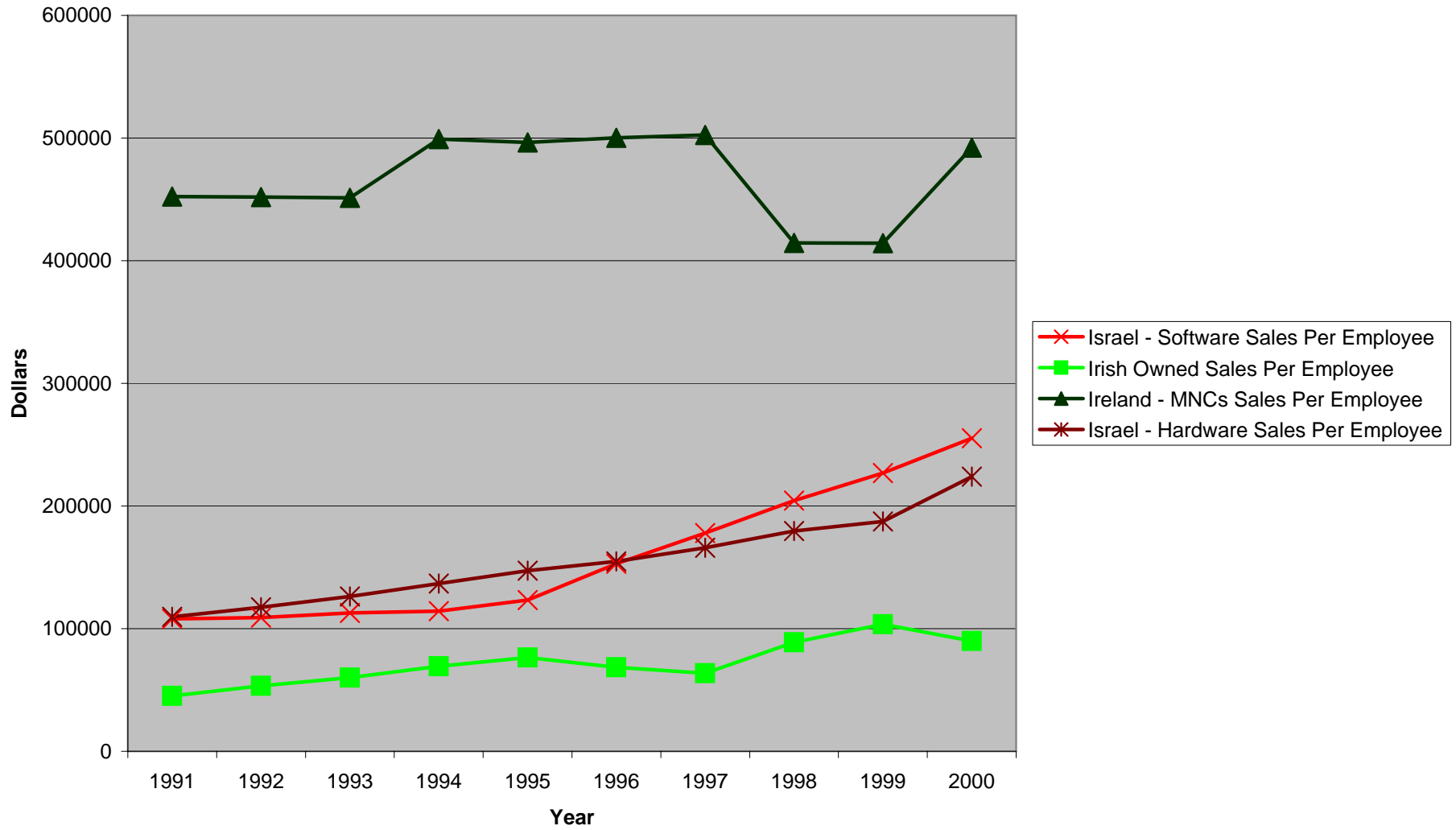
Source: National Informatics Directorate, Ireland, Israel Association of Software Houses, Israel Association of Electronics and Information Industries .
Note: Until 1997 data in Ireland was collected every two years

Total Employment Israel and Ireland



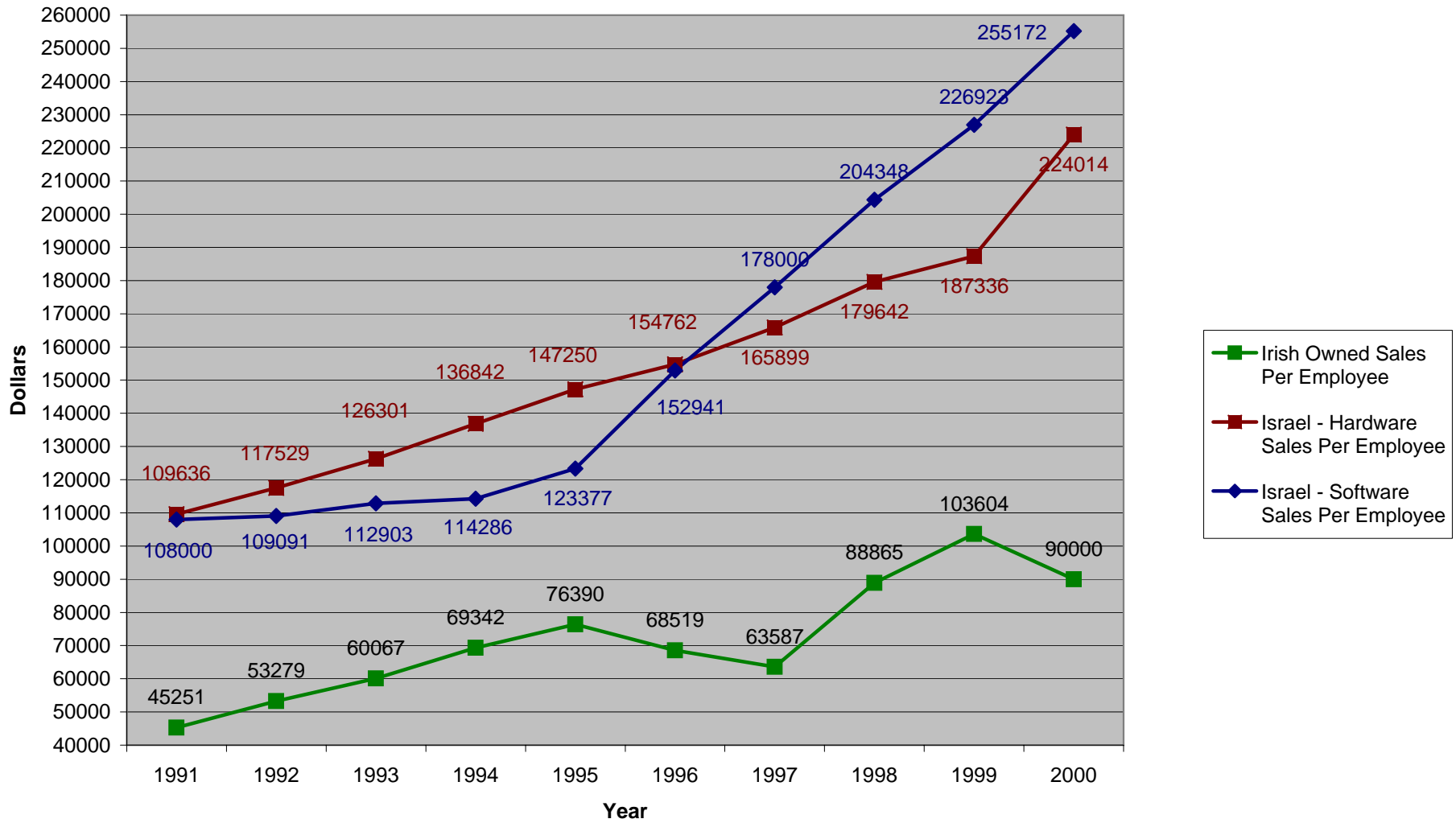
Source: National Informatics Directorate, Ireland, Israel Association of Software Houses, Israel Association of Electronics and Information Industries .
Note: Until 1997 data in Ireland was collected every two years

Sales Per Employee Figures



Source: National Informatics Directorate, Ireland, Israel Association of Software Houses, Israel Association of Electronics and Information Industries .
 Note: Until 1997 data in Ireland was collected every two years

Sales Per Employee - IT



Source: National Informatics Directorate, Ireland, Israel Association of Software Houses, Israel Association of Electronics and Information Industries .
 Note: Until 1997 data in Ireland was collected every two years

Venture Capital Raised in Israel 1991 - 2000

